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FOREWORD

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ABSTRACT

This document describes a collection of computer programs developed for use in research on human pattern perception. The overall orientation which guided the development of the VARGUS (Variable Generator of Unfamiliar Stimuli) pattern-generation programs and the historical backgrounds of each category (VARGUS 7, 9 and 10) are related in the first section. The second section provides documentation, sample output and summary for each program and subroutine.

CONTENTS

VARGUS PATTERN SYNTHESIS TECHNIQUES AND THEIR APPLICATIONS

SECTION I

THREE PATTERN-GENERATION SYSTEMS: THEIR CHARACTERISTICS AND APPLICATIONS

This collection of programs has been developed for use in research on pattern perception. The overall orientation which guided the development of these particular programs is schema theory as described by Evans (22). A pattern, in the context of schema theory, is a set of common characteristics or attributes associated with things belonging to the same pattern class. Individual instances of the class would not be identical nor would a particular instance necessarily exhibit all of the characteristics of the pattern.

A good example of such a pattern is a person's handwriting. Each person has a number of distinctive features associated with his handwriting. No feature is perfectly reliable in the sense that it is reproduced exactly in each handwriting sample. But taken together, the set of features is sufficient to permit a person's handwriting to be recognized or identified -- at least by experts.

The programs were intended to provide components of a methodology for studying human pattern perception. They are designed to offer the researcher options in choosing levels of familiarity and in controlling relevant stimulus parameters. To a substantial degree, these two options are mutually exclusive, because familiar stimuli are presumably encoded by subjects in terms of previously learned characteristics. Thus a determination of the relevant parameters would have to be based on a knowledge of human encoding processes--a knowledge which is, of course, not yet available. Unfamiliar patterns, on the other hand, can be designed in such a way that the subjects will find and respond to the parameters the experimenter has chosen to make relevant. (This assertion is supported in the studies discussed in later sections of this paper.) These generating systems are, therefore, useful in providing a range of choice with respect to these two properties.

The programs seem to have some fairly general utility for perception research, and this laboratory has received a number of requests either for programs or for copies of the stimuli. This document has been prepared to make the programs themselves more generally available. None of the programs are particularly difficult or complex. Most of them could be written rather quickly by any reasonably competent programmer. Nevertheless, experimenters may find it convenient to have the programs already available and debugged.

This set of programs may be subdivided into three general categories depending on the main pattern-generation program. These categories are: VARGUS 7, VARGUS 9 and VARGUS 10 (the term VARGUS was originally an acronym for Variable Generator of Unfamiliar Stimuli). In subsequent sections, each of the generating systems will be described in detail and some of its applications will be noted.

VARGUS 7

The VARGUS 7 system was designed to produce very unfamiliar patterns, but ones which allowed for substantial control and manipulation of relevant pattern parameters. The theory behind the system is given by Evans (24). The VARGUS 7 generates segments of a Markov process, and the theory of Markov processes is used to achieve a number of features which might be desirable in the study of pattern perception. It allows the sampling of unfamiliar stimuli from a defined population and permits the independent control of uncertainty (in bits per stimulus) and of redundancy. In the long run, all pattern elements occur with equal frequency in every pattern position (1st element, 2nd element, etc.). Moreover, one schema can be substituted for another without altering these characteristics.

The schema is expressed in the form of favored transitional probabilities from element to element; taken together, the set of favored elements constitutes a Most Probable Sequence (MPS). Different schemata are produced by choosing different permutations of the elements to constitute the MPS. The common characteristics of VARGUS 7 patterns are thus local features (pairs or triples of elements), and these are the only features that can be used to identify a particular pattern.

In the basic generating program, the elements of the Markov process are the integers from from 1 to 7. The resulting instances are strings of integers; final stimuli are produced by mapping the integers into other kinds of elements, as described below.

Table 1 gives parameter values to achieve selected levels of redundancy in generating VARGUS 7. The value $\underline{p}_{max}$ is used as the probability of the favored transition for each element; each of the other transitions is assigned a probability $(1 - \underline{p}_{max})/6$. Under these conditions, the redundancy and uncertainty of the Markov process are as given in Table 1.

TABLE 1

VARGUS 7 Control Table: Selected Redundancy Values and Corresponding Values of $\underline{H}$ and $\underline{p}_{max}$

Redundancy (Percent)	$\underline{H}$ (Bits per Column)	$\underline{p}_{max}$
0	2.81	.1428
20	2.24	.52
30	1.97	.61
40	1.69	.69
50	1.42	.76
60	1.10	.83
70	.84	.88
80	.55	.93

VARGUS 7 stimuli have been used most commonly by mapping the strings of numbers into column heights in histograms or altitudes in graphs (Fig. 1). In this latter form, the stimuli have some resemblance to time series data and their common characteristics are like transients occurring at random times.

These stimuli have been used in a substantial number of studies calling for subjects to distinguish between stimuli representing different schemata. It has been well established that subjects can accomplish this task (26, 15, 25, 19, 7).

Rosser (37) presented stimuli similar to those produced by the VARGUS 7 in an auditory format using the elements of the Markov processes to determine particular tone; she also found discrimination between classes of patterns, as did Copeland (13) with similar auditory patterns generated by the VARGUS 7 system. More recently Pollack (34) translated similar Markov processes into pulse trains, converted them to sound, and again demonstrated that subjects could spontaneously discriminate between classes of patterns. Similar effects were demonstrated by Hollier and Evans (31), using a language-like mode of presentation in which the elements of the Markov process were mapped into syllables.

The stimuli generated by the VARGUS 7 system have also been used in modeling efforts designed to emulate the behavior described above (21, 4, 8).

In addition to the basic demonstration of schematic concept formation, the VARGUS 7 stimuli have been used in a number of studies investigating the effect of constraint redundancy (23) and the effect of knowledge of results on schematic concept formation (10, 18, 20, 11, 39, 5). These studies have tended to show that constraint redundancy is an important variable in this context, and that schematic concept formation is accomplished reasonably well at 70 percent redundancy, marginally at 50 percent redundancy, and probably not at all at 40 percent redundancy. These figures, of course, apply to the kinds of stimuli used in the experiments--standard VARGUS 7 stimuli containing 12 to 24 elements and represented as histograms. There is no reason to expect a redundancy measure to have enough generality to permit its application to other kinds of patterns.

The effects of knowledge of results appear to be a bit more complex, but there is some suggestion (3, 41) that knowledge of results is ineffective and may actually interfere with performance when the patterns are sufficiently redundant (e.g., 70%). At lower redundancies, knowledge of results appears to facilitate performance.

Schema theory proposes that subjects remember an individual stimulus by encoding it in terms of its deviations from the schema. The VARGUS 7 stimuli have been used in studies of this question (16, 17, 32); there appears to be some evidence in support of the schema-plus-correction hypothesis when reproduction tasks are used. On the other hand, a study by Brown and Rebbin (10) tends to suggest that in pattern-classification tasks, at least, encoding of the schema plays very little role in the classification of the VARGUS 7 stimuli. Since encoding the schema is presumably a prerequisite to memory storage in the form of schema plus correction, further research on this point seems to be needed.

A set of VARGUS 7 patterns in numerical form has been prepared and made available (2); for many research purposes this standard set of VARGUS 7 stimuli would be suitable. That monograph also described a measure which allows each stimulus to be represented in terms of a single number indicating how closely it conforms to the prototype. This measure is computed by the subroutine ADHER, listed along with VARGUS 7.

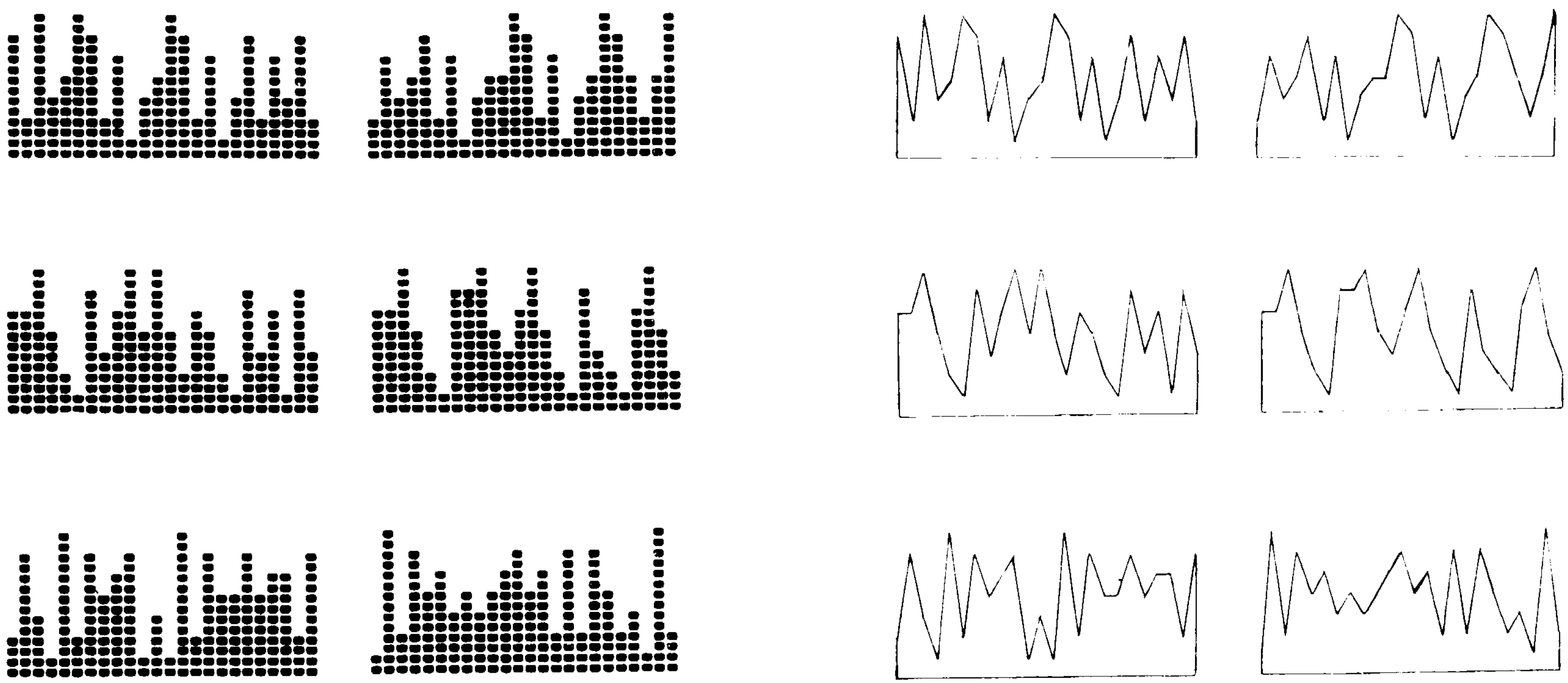

Fig. 1. SIX EXAMPLES OF VARGUS 7 PATTERNS PLOTTED AS HISTOGRAMS AND AS GRAPHS
(The histoform plots were produced by an IBM 1401 printer using the suppress-space feature to overprint the characters zero, capital O and asterisk. Each row represents a different schema.)

VARGUS 9

The VARGUS 9 stimuli are generated in accordance with a method described by Evans and Mueller (27). As with the VARGUS 7, the stimuli are randomly sampled from a defined population, with information and redundancy subject to control and manipulation. The following additional objectives were also achieved:

1. The population is made up of variants which consist of independent and measurable deviations from a defined prototype.

2. It is reasonable to treat the deviations as interval scale deviations from a mean, so that interval scale measures can be applied.

In the VARGUS 9 system a prototype is a string of integers ranging in value from 3 to 7. Any such string of no more than 32 elements will serve, although one would normally choose the string so as to avoid any systematic ordering of the integers. Variants are produced by adding to the prototype integer a deviation term, which is an integer ranging from -2 to +2. The probability distribution for this deviation is unimodally and symmetrically distributed about zero.

The procedure for determining the distribution of the deviation, as suggested by Evans and Mueller (27), is to choose $\underline{p}(0) = \underline{p}_{max}$ and then set the other values as follows:

$$\begin{aligned} \underline{p}(1) &= \underline{p}(-1- = (1-\underline{p}_{max})/3, \\ \underline{p}(2) &= \underline{p}(-2) = (1-\underline{p}_{max})/6. \end{aligned} \qquad [1]$$

Under these rules, the required values of $\underline{p}_{max}$ for selected redundancy levels are as given in Table 2. In general, the redundancy levels for exhibiting schematic concept formation are similar to those for VARGUS 7; 50 percent redundancy is marginal, while 70 percent gives relatively good results. As with the VARGUS 7, these comments apply only to the kinds of stimuli used in the studies reported below.

VARGUS 9 stimuli have been studied principally in displays mapping their numbers into column heights of histograms or into altitudes on a graph (Fig. 2). In this form, the stimuli might be likened to personality profiles or to other graphic displays in which the variability from column to column is relatively independent. In contrast to the VARGUS 7, the common characteristics of the VARGUS 9 stimuli lie in global features and in the overall shape. While local features are to some extent usable, they are less reliable than in comparable VARGUS 7 stimuli.

These stimuli have also been used in studies of schematic concept formation (35, 29, 30). Again, the research has shown schematic concept formation to occur and there is some possibility that it is easier with VARGUS 9 stimuli than with VARGUS 7 stimuli (40). These stimuli have also been used in polar-coordinate form (33, 1) in which the numbers constituting the patterns are plotted as length of radii. In this form they constitute a closed polygon, and research with them has provided a link between schematic concept formation studies and the Brown and Owen psychophysics of form (12). Aiken and Brown (1) have extended this research with a modified version of the VARGUS 9 pattern-generating system (Fig. 3). One of the major results of this research has been the demonstration of subjects' sensitivity to the statistical distributions of features within the particular set of patterns on which judgments are being made. Similar effects have been shown by Dansereau, Fenker and Evans (14), who demonstrated that pattern storage in memory is substantially influenced by the clusters of patterns constituting schema families.

TABLE 2

VARGUS 9 Control Table: Values of p_{max} to Achieve Selected Levels of Constraint Redundancy

Redundancy	p_{max}
30%	.31
40%	.53
50%	.66
60%	.77
70%	.84

The perceived similarity of VARGUS 9 stimuli, when they are drawn from the same cluster, or schema family, appears to be determined largely by the Euclidean distance between the pair of stimuli (36); a correlation of .88 was found between judged similarity and interpoint distance. (This quantity is calculated by the subroutine DVAR, listed with VARGUS 9.) The strength of this relationship supports the assertion that interval scale measures are appropriate with VARGUS 9 stimuli and suggests that these stimuli might have some general usefulness in cases where it is desirable to control the subjective similarity of patterns.

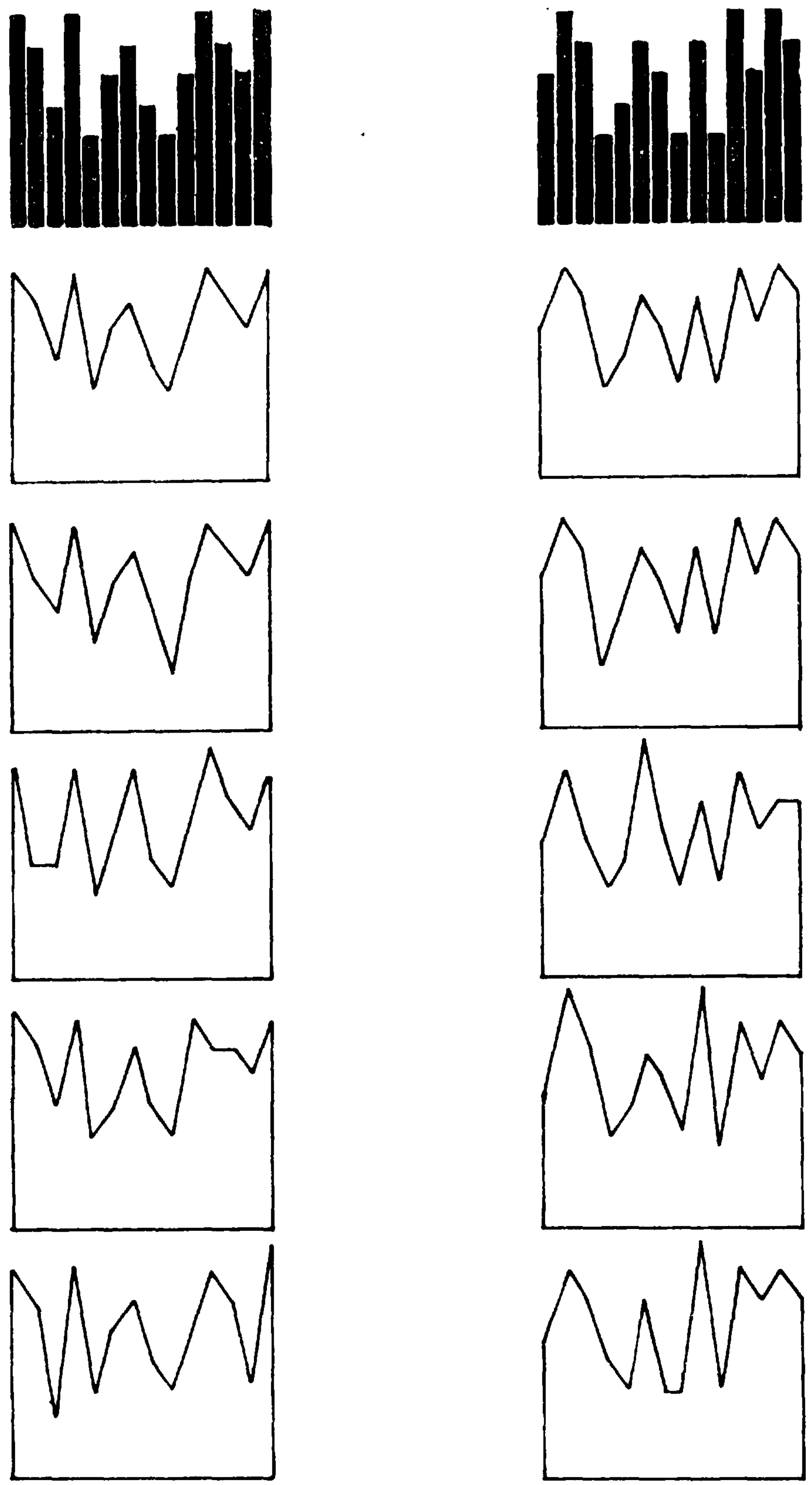

Fig. 2. EXAMPLES OF VARGUS 9 PATTERNS IN HISTOGRAMS AND GRAPHIC FORMAT
(Each column represents a different schema. The histograms and the topmost graphs are prototypes. Instances below these represent increasing deviations from the prototypes.)

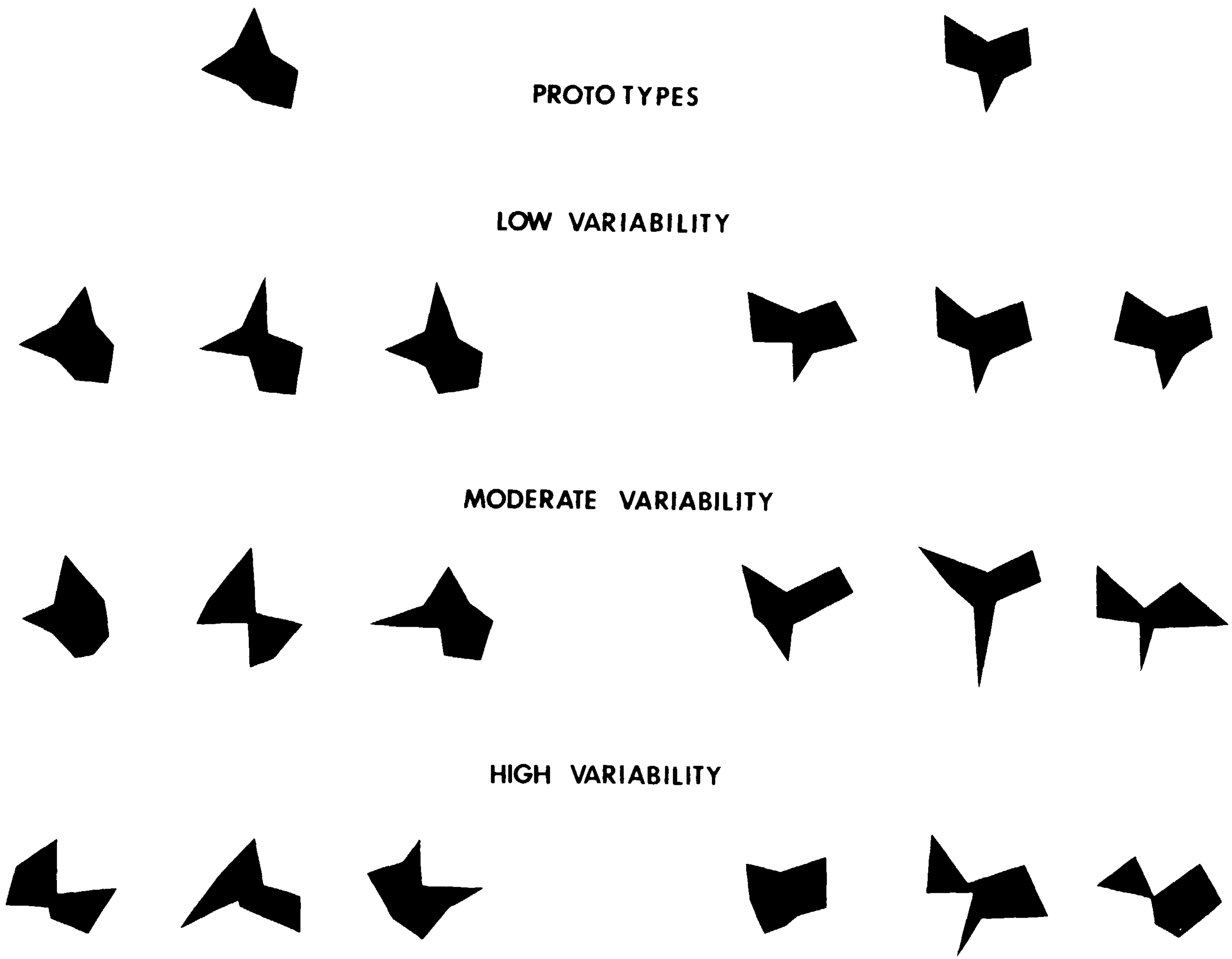

Fig. 3. EXAMPLES OF POLYGONS PRODUCED BY A MODIFICATION OF THE VARGUS 9 SYSTEM DEVELOPED BY AIKEN, L. S. & BROWN, D. R. (1)

VARGUS 10

The previous generating programs produced stimuli that were intended to be relatively unfamiliar. The VARGUS 10 system was designed to provide stimuli which are of intermediate familiarity. In particular, the VARGUS 10 patterns are intended to incorporate relatively familiar components into overall configurations which are relatively unfamiliar.

The method for obtaining familiar configurations was based on a method devised by Shannon and Weaver (38). In studying the transitional probabilities of English grammar, Shannon used humans as repositories of the statistical characteristics of grammar. In the same way, one might expect that humans are repositories of the statistical characteristics of the visual environment and that they use these characteristics when they draw figures. In accord with that logic, a commercial artist was engaged to draw a number of figures in such a way as to allow them to be decomposed into interchangeable components.

The original drawings were made in a 3 x 3 matrix (Fig. 4); the eight outer cells of the matrix had marks on the midpoints of the lines separating them from their adjoining cells. The artist was instructed to draw each figure by starting at one of the midpoints and drawing any line he pleased through the cell, so long as the line did not touch itself and did not cross the border of the cell except at the other midpoint, where the line could exit to the next cell. He was then to continue in the same fashion through the remaining cells until he returned to the starting point. He was encouraged to produce any familiar figures he could within those constraints.

The resulting drawings were then decomposed by taking the configuration in each cell as a separate unit. the matrix had four "corner" cells and four "side" cells. Since all corner cells, if properly rotated, had the same entry and exit points for the line, any corner cell could be used in any corner to construct a figure. The same condition applied to the side cells.

After the components were dissociated from their source figures, they were reviewed to eliminate components which were near duplicates of each other and to eliminate components which contained too much detail to be adequately represented by black dots in a 16 x 16 matrix. The resulting set--40 corner components and 34 side components--constituted the basic set out of which patterns could be generated.

The VARGUS 10 program selects components at random from these sets to fill each of the four corner cells and four side cells of a figure being constructed. The components are rotated to conform to the orientation of the assigned cells, and each component is then placed to comprise a 16 x 16 sub-matrix of a 48 x 48 matrix which contains the whole pattern (Fig. 5).

A number of associated programs have been prepared to manipulate the VARGUS 10 stimuli and to provide a measure--probably a crude one--of similarity. these programs are also provided in the VARGUS 10 section.

The VARGUS 10 generating system has not been the subject of as many published reports as have the VARGUS 7 and VARGUS 9. Stimuli generated with this system were used in conjunction with the elements of a model for human preprocessing by Zinser (42, 43), and they have been used in a study of feature selection by Hastings and Evans (28). This latter study established a methodology for obtaining judgments from people regarding the features they would use for discriminating patterns; the results indicated a preference for corner configurations and for projections.

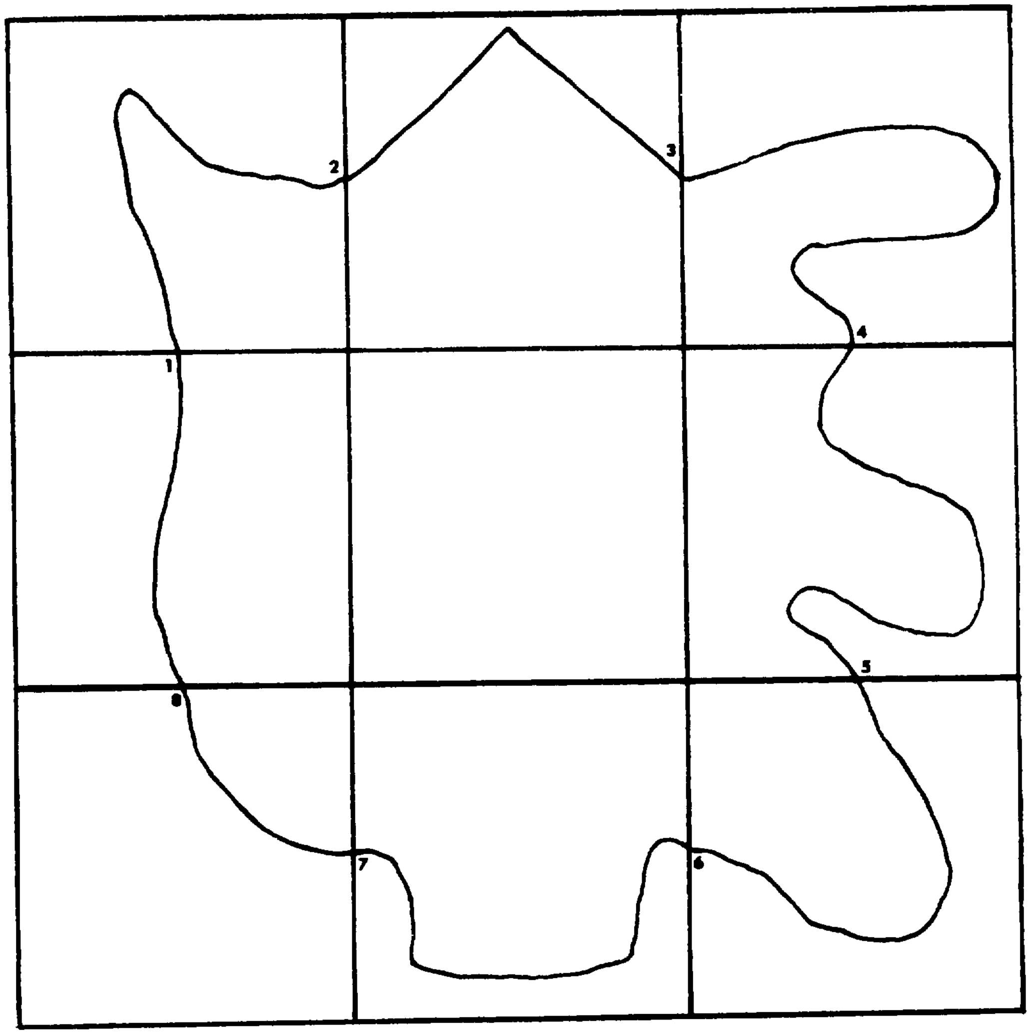

Fig. 4. EXAMPLE OF A DRAWING PREPARED BY AN ARTIST UNDER INSTRUCTIONS TO PRODUCE FAMILIAR FIGURES UNDER CONSTRAINTS DESCRIBED IN THE TEXT
(The drawing was termed "Old Witch.")

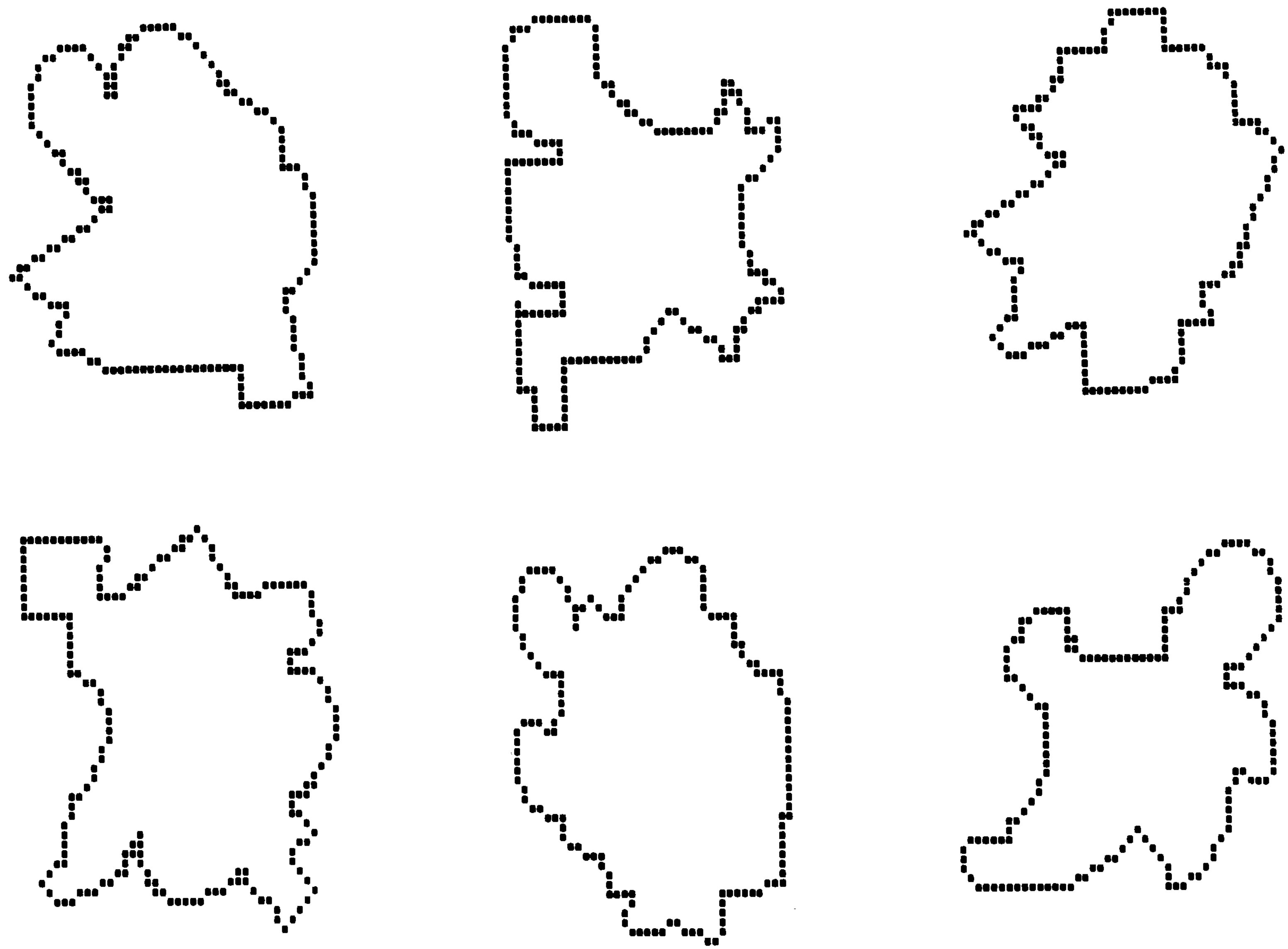

Fig. 5. EXAMPLES OF VARGUS 10 PATTERNS

A number of other studies of feature selection are possible with the VARGUS 10 stimuli; these studies have not been executed under the present research project only because other studies were of higher priority for the purposes of the project. For example, no study has been carried out to assess the adequacy of the similarity measure computed by CONG; doubtless, such a study would be of substantial interest.

One might assess the effectiveness of the overall similarity measure in predicting subjective similarity. One might also measure the similarity of the individual components and use these values in a regression equation to compare their predictive power with the predictive power of the overall similarity measure. (The difference between these two prediction methods is that the first assumes that the whole is the sum of its parts, while the second assumes that the whole is the best weighted linear combination of its parts.) One could also obtain subjective judgments of the similarities of the parts to determine the relative adequacy of these measures in predicting overall similarity as compared with the objective similarity measures. Such studies would shed additional light on the processes of feature selection and feature utilization.

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SECTION II

INTRODUCTION TO VARGUS PATTERN GENERATION PROGRAMS

The purpose of this introduction to the documentation is to familiarize the reader with the overall content of the programs that follow and to discuss certain programming considerations not relevant to the description of the programs and thus not discussed in the documentation. The following pages contain the documentation for 21 programs and subroutines that have been used for the computer generation, measurement, manipulation and construction of the VARGUS 7, 9 and 10 patterns. These programs have been used on many occasions in the past, and the program listings in the documentation are exactly those programs which produced the sample outputs.

All programs are written in IBM 1800 Basic FORTRAN IV except program PAT which is written in AUTOCODER for the IBM 1401. In principle, the FORTRAN programs should be translated readily by FORTRAN compilers, regardless of the particular machine and implementation, especially since a USA Standard Basic FORTRAN IV is an accepted standard for the language. In fact, implementations of compilers and semantics of program statements frequently are different enough to prevent direct communication of programs between machines. We will now discuss some of the more common incompatibilities which the user may experience in attempting to utilize IBM 1800 Basic FORTRAN IV on other machines and briefly indicate how to correct them when they occur.

Probably the primary source of incompatibility a user will experience with these programs is the mixed mode arithmetic expressions. Standard FORTRAN does not permit mixed-mode expressions. The semantics of mixed expressions contained in these programs are as follows:

a. All terms in a mixed expression involving only floating-point variables are evaluated with floating-point arithmetic.

b. All terms in a mixed expression involving only integer-mode variables are evaluated with integer arithmetic.

c. When a mixed expression contains terms that involve both integer and floating-point variables, the integer quantities are converted to floating point before performing the floating-point arithmetic. Consider the mixed expression A * B + I/J - C/(I + J). It is evaluated as follows:

a. A * B is evaluated in floating point, and the product is a floating-point number.

b. I/J is an integer division so that any fractional remainder after division is lost, and the integer part of the quotient is saved as an integer-mode result.

c. In C/(I + J), (I + J) is evaluated with integer arithmetic, but before the division occurs the sum is converted to floating point, and the division is performed by floating-point arithmetic and yields a floating-point quotient.

d. The floating-point product of A * B is then added to the quotient of I/J after the latter has been converted to floating point (the sum is a floating-point number), and finally,

e. The floating-point quotient of C/(I + J) is then subtracted from the result of "d" to obtain a floating-point difference.

The user should note that an equivalent evaluation of this expression is not achieved by simply changing it to A * B + FLOAT(I)/FLOAT(J) - C/(FLOAT(I) + FLOAT(J)) since the middle quotient now may include a fractional part. When every term in an expression is either mixed or floating point (no integer terms) such a transformation will suffice. The numerical result of any mixed expression is always in floating-point mode.

Another source of incompatibility may result from the use of apostrophes to enclose literal data in Format statements. An equivalent representation may be achieved by using the H-format code.

Finally the DATA specification statement which initializes variables at compile time is not a USA Standard Basic FORTRAN IV feature. If this is a basis for an incompatibility, the initialization may be done with an input statement at execution time.

There are other ways in which IBM 1800 Basic FORTRAN IV differs from USA Standard Basic FORTRAN IV but they should not be the basis for incompatibilities. For example, 1800 FORTRAN IV variable names are limited to a length of five characters, whereas the more common length is six characters. Other incompatibilities of this innocuous sort are not discussed here.

For the readers' information, the logical unit numbers referenced in input-output statements in the program are associated with the following devices: logical unit 2 is the card reader-punch. logical unit 3 is the line printer, logical units 8 and 9 are tape drives. When no format number is associated with input-output from tape, all data transfer is in binary and involves no conversion.

One brief note should be made to users who may desire to convert these programs to FORTRAN II. In some programs, Type specification statements are used which alter the implicit mode of a variable, for example, INTEGER PATR permits PATR to be used as an integer mode variables. Since FORTRAN II does not implement Type statements, the desired mode may be obtained by adding an appropriate leading letter to the variable name, for example, KPATR. Also FORTRAN IV input-output statements which reference logical-unit numbers will have to be changed to reference Format statements only, and in output statements in particular the Format statement will have to be adjusted if no carriage control is needed. The apostrophes to define literal data will also have to be changed to an H-format code. Finally the DATA statement which initialize certain variables at compile time will have to be deleted and changed to initialization by means of an input statement.

An overview of the programs will illustrate their organization and interrelationships. In the Appendix, the term "Program Name" indicates the associated routine is a main program and the term "Subroutine Name" indicates the routine is a subroutine program. To the right of each routine's name is a brief statement of its purpose. When a routine's name is indented to the right relative to the routine name above it, the indented name is a subroutine called by the routine above it. It should be noted that there are subroutines below without an associated calling routine. Since the calling routines were relatively trivial (restricted largely to doing input and output) they were selectively excluded. Finally, sample executions are not included for each and every subroutine, since in many instances their function is minor and supporting a larger goal. Sample runs are included only for each composite of routines with a major objective.

APPENDIX

SUMMARY OF VARGUS PROGRAMS

Vargus 7

Program Name:	VARGUS 7E	Pattern generation.
Program Name:	ADHER	Pattern measurement.
Program Name:	PAT	Pattern construction.

Vargus 9

Program Name:	VARGUS 9	Pattern generation and measurement.
Program Name:	VARG 9	Pattern generation and measurement.
Program Name:	DVAR	Pattern measurement and construction.

Vargus 10

Program Name:	VARGUS 10A	Input submatrices and output pattern image.
Subroutine Name:	JOIN	Select submatrices.
Subroutine Name:	ROTAT	Rotate submatrices.
Subroutine Name:	MODUL	Perform modular arithmetic.

Subroutine Name:	CONG	Measure pattern similarity.
Subroutine Name:	BLUR	Blurs the input pattern.
Subroutine Name:	RSCAL	Rescale numbers in matrix.
Subroutine Name:	MIMAX	Find largest and smallest value in a matrix.

Subroutine Name: SOLID	Fill in figure defined by a perimeter of ones.

Subroutine Name: WIDEN	Widen the lines of a figure.

Subroutine Name: WIDER	Widen lines of a closed figure inwardly.

Subroutine Name: SOLID

Subroutine Name: WIDEN

<u>General</u> <u>Purpose</u> <u>Programs</u>

Subroutine Name: RANDY	Pseudo-random number generator.
Subroutine Name: PATOT	Output pattern matrix.

I. Identification

1. Program Name: VARGUS 7E
2. Category: Pattern Generation
3. Purpose: Generate strings of numbers containing first-order sequential (Markov) dependency.
4. Date: September 8, 1970
5. Programmer: Selby Evans

II. Use Information

1. Language: 1800 Basic FORTRAN IV.
2. Machine: IBM 1800, 32K, 16-bit words.
3. Limitations: Elements of the Markov process are the numbers 1 to 9.
   Reuse of the same START card for the random-number generator will produce the same number sequence.
4. Input Data:

   The first call to Subroutine RANDY results in the START card being read in. See RANDY documentation for details of its usage.

   LNTH: The number of digits constituting a single pattern.

   INTL: The identification number assigned to the first instance.

   INST: The number of pattern instances desired.

   LEAD: The first pattern element (digit from 1 to 9) in each pattern. If LEAD = 0, the first

pattern element is chosen at random for each pattern.

NCØL: Number of elements in the Markov process. Maximum allowable in this program is NCØL = 9.

P: An NCØL x NCØL Markov matrix. Each data-card input to P is one row of P.

5. Output Data:

Final pattern is contained in array L and is output on the printer.

6. Subroutines Required:

RANDY: A pseudo-random number generator.

III. Mathematical Methods and References

See Evans, S. H. "A model for perceptual category formation." Unpublished doctoral dissertation, Texas Christian University, 1964.

Evans, S. H. VARGUS 7: Computer patterns from Markov Processes. Behavioral Science, 1967, 12, 323-328.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
// JOB                 11000    30 JUN 71 13.404 HRS
// * U-2050-003
// FOR ABBA    30 JUN 71 13.405 HRS
*IOCS (CARD,1443 PRINTER,PLOTTER,DISK,MAGNETIC TAPE,KEYBOARD,TYPEWR
*NONPROCESS PROGRAM
*LIST ALL
*ONE WORD INTEGERS
C    VARGUS 7-E
      DIMENSION P(9,9),L(60)
      CALL RANDY(R)
      WRITE(3,901)
  901 FORMAT('1',T7,'SAMPLE VARGUS SEVEN PATTERNS')
      WRITE(3,911)
  911 FORMAT('0',T9,'ID',T21,'PATTERNS',/)
C
C     ENTER CONTROL CARDS AND MATRIX
      READ(2,4) LNTH,INTL,INST,LEAD,NCOL
4     FORMAT(5I5)
      INST = INST + INTL - 1
      DO 10 I=1,NCOL
10    READ(2,5) (P(I,J),J=1,NCOL)
5     FORMAT(9F8.4)
C
C     SET UP POPULATION LOOP
      X=NCOL
      X=1.0/X
      DO 90 NDO = INTL,INST
      DO 20 K=1,40
20    L(K)=0
C
C     CHOOSE STARTING ELEMENT
      MARK = LEAD
      IF(LEAD) 30,30,50
30    CALL RANDY(R)
      DO 40  MARK =1,NCOL
      R = R - X
      IF(R) 50,50,40
40    CONTINUE
      MARK= NCOL
C
C     SET UP INSTANCE LOOP
50    DO 80 IDO =1,LNTH
      L(IDO)= MARK
C
C     MOVE ONE STEP
      CALL RANDY(R)
      DO 60 K= 1,NCOL
      R = R - P(MARK,K)
      IF(R) 70,60,60
60    CONTINUE
      K = NCOL
70    MARK = K
80    CONTINUE
C
```

```
C       PRINT RESULTING PATTERN AND ID ON PRINTER
        WRITE(3,9) NDO,(L(I),I=1,LNTH)
9       FORMAT(4X,I7,3X,12(1X,4I1))
90      CONTINUE
        CALL EXIT
        END

VARIABLE ALLOCATIONS
      P(R )=00A0-0000     R(R )=00A2          X(R )=00A4          L(I )=00E1
   INST(I )=00E4       LEAD(I )=00E5       NCOL(I )=00E6          I(I )=00E7
      K(I )=00EA       MARK(I )=00EB        IDO(I )=00EC

STATEMENT ALLOCATIONS
 901   =00F5  911   =0108  6     =0115  5     =0118  9     =011B  10    =0149  20
 60    =01DD  70    =01EA  80    =01EE  90    =0210

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS
 IOCS

CALLED SUBPROGRAMS
 RANDY    FSUB     FSUBX    FDIV     FLD      FSTO     FLOAT    ISTOX    LDFAC    MR
 SUBSC    FCHRI    TYPEN    HOLEB    MAGT     PRNTN    EBPRT    CARDN

REAL CONSTANTS
  .100000E 01=00EE

INTEGER CONSTANTS
     3=00F0        2=00F1        1=00F2       40=00F3        0=00F4

CORE REQUIREMENTS FOR ABBA
 COMMON        0  INSKEL COMMON        0
  VARIABLES     238   PROGRAM     302



END OF COMPILATION
```

SAMPLE VARGUS SEVEN PATTERNS

ID	PATTERNS			
1001	1731	1725	3153	45
1002	7263	1727	2664	53
1003	4531	7726	7645	37
1004	5353	1726	4531	74
1005	3517	2645	3453	17
1006	7264	1717	2617	26
1007	7253	1726	4531	76
1008	2647	2645	1726	45
1009	1726	4574	5726	45
1010	5317	2641	7131	56

I. Identification

1. Program Name: ADHER

2. Category: Pattern Measurement.

3. Purpose: The program measures the degree to which a pattern generated by program VARGUS 7E adheres to the schema rule from which it was generated. See Section III below.

4. Date: May 17, 1971

5. Programmer: Mike Abbamonte

II. Use Information

1. Language: 1800 Basic FØRTRAN IV.

2. Machine: IBM 1800, 32K, 16-bit words.

3. Limitations: As written, the program will measure patterns generated from a seven-element Markov Process. Adjustment in the size of arrays MPS and MX will make the program more general.

4. Input Data:

NCØL: The length (number of digits in) an individual pattern.

LMPS: The length of the most probable sequence before cycling. Should be seven here.

NPAT: The number of patterns to be measured.

MPS: A vector containing the schema; i.e., the most probable sequence.

IDPAT: Individual pattern identification number.

IN: The array containing the pattern.

5. Output Data:

IDPAT: Same as above.

IN: Same as above.

PSS: The proportion of schematic steps. See Section III for details.

6. Subroutines Required:

None.

III. Mathematical Method and References

The proportion of schematic steps (PSS) is the measure used to indicate the degree to which a pattern adheres to its generation rule (also called the MPS; i.e., most probable sequence). PSS is simply that fraction of the number of elements in a pattern which are followed by the most probable successor element.

See also, Evans, S. H. VARGUS 7: Computer patterns from Markov processes. Behavioral Science, 1967, 12, 323-328.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
// JOB    30 JUN 71 13.438 HRS
// * U-2050-003
// FOR ABBA    30 JUN 71 13.438 HRS
*NONPROCESS PROGRAM
*ONE WORD INTEGERS
*IOCS (CARD,1443 PRINTER,PLOTTER,DISK,MAGNETIC TAPE,KEYBOARD,TYPEWRITER)
*LIST ALL
C   ADHER
      DIMENSION IN(24),MPS(7),MX(7,7)
      READ(2,2) NCOL, LMPS,NPAT
2     FORMAT(3I5)
      FCOL=NCOL
      READ(2,3) (MPS(I),I=1,LMPS)
3     FORMAT(20I3)
      WRITE(3,88)
   88 FORMAT('1',T3,'ID',T28,'VARGUS SEVEN PATTERNS',T60,'PROPORTION OF
     1SCHEMATIC STEPS',/)
      DO 500 I=1,NPAT
      READ(2,5) IDPAT, (IN(J),J=1,NCOL)
5     FORMAT(I5,5X,20(I1,1X))
      DO 200 K1=1,LMPS
      DO 200 K2=1,LMPS
200   MX(K1,K2)=0
      DO 100 L=1,NCOL
      IR=IN(L)
      IF(L-NCOL) 60,70,60
60    IC=IN(L+1)
      GO TO 100
70    IR=IN(1)
100   MX(IR,IC)=MX(IR,IC)+1
      ICNT=0
      DO 150 L=1,LMPS
      IR=MPS(L)
      IF(L-LMPS) 120,130,120
130   IC=MPS(1)
      GO TO 150
120   IC=MPS(L+1)
150   ICNT=ICNT+MX(IR,IC)
      FCNT=ICNT
      PSS=FCNT/FCOL
      WRITE(3,30) IDPAT, (IN(L),L=1,NCOL), PSS
   30 FORMAT(I5,10X,14I3,12X,F8.4)
500   CONTINUE
      CALL EXIT
      END

VARIABLE ALLOCATIONS
  FCOL(R )=0000        FCNT(R )=0002        PSS(R )=0004        IN(I )=001D
  NCOL(I )=0056        LMPS(I )=0057       NPAT(I )=0058         I(I )=0059
    K1(I )=005C          K2(I )=005D          L(I )=005E        IR(I )=005F

STATEMENT ALLOCATIONS
 2     =0068  3     =006B  88    =006E  5     =0093  30    =009A  200   =00F0  60
 120   =0166  150   =016F  500   =01AB
```

```
FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS
 IOCS

CALLED SUBPROGRAMS
 FDIV     FLD      FSTO     FLOAT    ISTOX    MRED     MWRT     MCOMP    MIOIX    MI(
 MAGT     PRNTN    EBPRT    CARDN

INTEGER CONSTANTS
      2=0064        1=0065        3=0066        0=0067

CORE REQUIREMENTS FOR ABBA
 COMMON        0   INSKEL COMMON        0
  VARIABLES      100   PROGRAM      338


END OF COMPILATION
```

ID	VARGUS SEVEN PATTERNS														PROPORTION OF SCHEMATIC STEPS
1001	1	7	3	1	1	7	2	5	3	1	5	3	4	5	0.5714
1002	7	2	6	3	1	7	2	7	2	6	6	4	5	3	0.7142
1003	4	5	3	1	7	7	2	6	7	6	4	5	3	7	0.6428
1004	5	3	5	3	1	7	2	6	4	5	3	1	7	4	0.7857
1005	3	5	1	7	2	6	4	5	3	4	5	3	1	7	0.7142
1006	7	2	6	4	1	7	1	7	2	6	1	7	2	6	0.7142
1007	7	2	5	3	1	7	2	6	4	5	3	1	7	6	0.7857
1008	2	6	4	7	2	6	4	5	1	7	2	6	4	5	0.7857
1009	1	7	2	6	4	5	7	4	5	7	2	6	4	5	0.7142
1010	5	3	1	7	2	6	4	1	7	1	3	1	5	6	0.5714

I. Identification

1. Program Name: PAT
2. Category: Pattern Construction
3. Purpose: Punch histograms of VARGUS 7 patterns on cards by utilizing the punch-column binary feature of the IBM 1401.
4. Date: September 26, 1968
5. Programmer: Phillip R. Jones

II. Use Information

1. Language: IBM 1401 Autocoder Ver. 1, mod. 13.
2. Machine: IBM 1401, 1402, and 1407 with punch-column binary feature.
3. Limitations: Punches maximum column height of 7.
4. Input Card: Columns 3-7 identification number. Columns 14-67 digits specifying pattern column heights.
5. Output: Columns 1-72 VARGUS 7 histogram. Columns 76-80 identification number.
6. Operating Instructions: Sense switch "B" off generates one column per digit; "B" on generates two columns per digit.
7. Subroutines Required: None.
8. Error Checks: ID - checks card columns 3-7 for blank.

   Input - checks for invalid characters.

III. Mathematical Method and References

None.

IV. Listing of Source Program

Attached.

V. Flow Chart

Attached.

VI. Sample Run

Not attached.

VII. Remarks

Testing has been extensive and all attempts to punch incorrect patterns have failed.

CROSS REFERENCE LISTING

ADDRS	LABEL	TAG	SEQUENCE NUMBERS OF INSTRUCTIONS WHERE SYMBOL APPEARS							
00618	BEGIN		0007	0034	0078	0105	0110			
01245	EOJ		0111	0107						
01298	GM		0113	0006	0089	0092	0095	0097	0137	0138
			0146	0148	0149					
00660	P0112		0017	0022	0057					
00698	P0117		0023	0018						
00790	P0209		0035	0023						
00801	P0211		0037	0024						
00812	P0213		0039	0025						
00823	P0215		0041	0026						
00834	P0217		0043	0027						
00845	P0219		0045	0028						
00856	P0301		0047	0029						
00867	P0303		0049	0030						
00878	P0305		0051	0031						
00889	P0307		0053	0032						
00896	P0308		0054	0036	0038	0040	0042	0044	0046	0048
00936	P0314		0060	0067	0102	0104	0156	0158		
00987	P0401		0069	0062						
01063	P0412		0080	0069						
01081	P0415		0083	0070						
01092	P0417		0085	0071						
01103	P0419		0087	0072						
01114	P0501		0089	0073						
01132	P0504		0092	0074						
01150	P0507		0095	0075						
01161	P0509		0097	0076						
01175	P0511		0099	0082	0084	0086	0088	0091	0094	0096
01213	P0517		0105	0065	0157					
01218	P0519		0107	0007						
01233	P0601		0109	0021	0123	0154				
01299	P0701		0115	0061						
01367	P0711		0125	0115						
01385	P0714		0128	0116						
01403	P0717		0131	0117						
01421	P0720		0134	0118						
01439	P0803		0137	0119						
01457	P0806		0140	0120						
01489	P0811		0145	0121						
01507	P0814		0148	0122						
01535	P0818		0152	0127	0130	0133	0136	0139	0144	0147
00600	START		0004	0159						
00089	X1		IIII	0013	0019	0055	0058	0066	0099	0152
00094	X2		IIII	0014	0020	0056	0059	0100	0153	

```
     PT219               COLUMN BINARY PATTERN BUILDER  VER 2 MOD 1

SEQ  PGLIN LABEL   OPCD  OPERAND                                   A/C V1-M13

0001 01020 PT219   JOB   COLUMN BINARY PATTERN BUILDER  VER 2 MOD 1
0002 01023         CTL   4111       S
0003 01025         ORG   600
0004 01030 START   SW    1,87
0005 01040         SW    92
0006 01050         MLCWA GM,81
0007 01060 BEGIN   BLC   P0519                TEST LAST CARD
0008 01061         CW    201
0009 01070         R                         READ A CARD
0010 01071         BIN   *+5,B
0011 01072         B     *+5
0012 01073         SW    201
0013 01080         SBR   X1,3
0014 01090         SBR   X2,75
0015 01100         CS    599                  CLEAR BINARY AREA
0016 01110         CS
0017 01120 P0112   BCE   *+5,0+X1,           TEST FOR BLANKS
0018 01125         B     P0117               BRANCH ON GOOD ID
0019 01130         SBR   X1,1+X1
0020 01140         SBR   X2,1+X2
0021 01150         BCE   P0601,089,8         TEST FOR ID LENGTH ERROR
0022 01160         B     P0112
0023 01170 P0117   BCE   P0209,0+X1,0        TEST FOR ZERO
0024 01180         BCE   P0211,0+X1,1                 ONE
0025 01190         BCE   P0213,0+X1,2                 TWO
0026 01200         BCE   P0215,0+X1,3                 THREE
0027 02010         BCE   P0217,0+X1,4                 FOUR
0028 02020         BCE   P0219,0+X1,5                 FIVE
0029 02030         BCE   P0301,0+X1,6                 SIX
0030 02040         BCE   P0303,0+X1,7                 SEVEN
0031 02050         BCE   P0305,0+X1,8                 EIGHT
0032 02060         BCE   P0307,0+X1,9                 NINE
0033 02070         WCP   1
0034 02080         B     BEGIN
0035 02090 P0209   MLNS  '8',400+X2          BUILD COLUMN BINARY ZERO
0036 02100         B     P0308
0037 02110 P0211   MLNS  '4',400+X2                              ONE
0038 02120         B     P0308
0039 02130 P0213   MLNS  '2',400+X2                              TWO
0040 02140         B     P0308
0041 02150 P0215   MLNS  '1',400+X2                              THREE
0042 02160         B     P0308
0043 02170 P0217   MLZS  'J',500+X2                              FOUR
0044 02180         B     P0308
0045 02190 P0219   MLZS  'Z',500+X2                              FIVE
0046 02200         B     P0308
0047 03010 P0301   MLNS  '8',500+X2                              SIX
0048 03020         B     P0308
0049 03030 P0303   MLNS  '4',500+X2                              SEVEN
0050 03040         B     P0308
0051 03050 P0305   MLNS  '2',500+X2                              EIGHT
0052 03060         B     P0308
```

```
SEQ  PGLIN LABEL   OPCD  OPERAND                                   A/C V1-M13

0053 03070 P0307   MLNS  '1',500+X2                                  NINE
0054 03080 P0308   BCE   *+19,89,7
0055 03081         SBR   X1,1+X1
0056 03082         SBR   X2,1+X2
0057 03090         B     P0112
0058 03120         SBR   X1,14              REINITIALIZE X1=014
0059 03130         SBR   X2,1                            X2=001
0060 03140 P0314   BCE   *+13,0+X1,         TEST FOR BLANK DATA COLUMN
0061 03145         BW    P0701,201          TEST FOR DOUBLE COLUMN
0062 03147         B     P0401
0063 03150         BCE   *+5,88,6            TEST FOR LAST COLUMN
0064 03160         B     *+9
0065 03170         BCE   P0517,89,7
0066 03180         SBR   X1,1+X1            INCREMENT NEXT COLUMN
0067 03190         B     P0314
0068 03200 *                          COLUMN BINARY PATTERN BUILD
0069 04010 P0401   BCE   P0412,0+X1,0       TEST FOR ZERO
0070 04020         BCE   P0415,0+X1,1                ONE
0071 04030         BCE   P0417,0+X1,2                TWO
0072 04040         BCE   P0419,0+X1,3                THREE
0073 04050         BCE   P0501,0+X1,4                FOUR
0074 04060         BCE   P0504,0+X1,5                FIVE
0075 04070         BCE   P0507,0+X1,6                SIX
0076 04080         BCE   P0509,0+X1,7                SEVEN
0077 04090         WCP   1                  PATTERN ERROR
0078 04100         B     BEGIN
0079 04110 *                             BUILD BINARY COLUMN - SINGLE
0080 04120 P0412   MLC   ' ',400+X2         ZERO
0081 04130         MLC   ' ',500+X2
0082 04140         B     P0511
0083 04150 P0415   MLNS  '1',500+X2         ONE (1-BIT)
0084 04160         B     P0511
0085 04170 P0417   MLNS  '3',500+X2         TWO (1,2-BITS)
0086 04180         B     P0511
0087 04190 P0419   MLNS  '7',500+X2         THREE(1,2,4-BITS)
0088 04200         B     P0511
0089 05010 P0501   MLC   GM,500+X2          FOUR (1,2,4,8-BITS)
0090 05020         MLZS  ' ',500+X2
0091 05030         B     P0511
0092 05040 P0504   MLC   GM,500+X2          FIVE (1,2,4,8,A-BITS)
0093 05050         MLZS  'Z',500+X2
0094 05060         B     P0511
0095 05070 P0507   MLC   GM,500+X2          SIX (1,2,4,8,A,B-BITS)
0096 05080         B     P0511
0097 05090 P0509   MLC   GM,500+X2          SEVEN(1,2,4,8,A,B,1-BITS)
0098 05100         MLNS  '1',400+X2
0099 05110 P0511   SBR   X1,1+X1            INCREMENT TO NEXT COLUMN
0100 05120         SBR   X2,1+X2
0101 05130         BCE   *+5,88,6           TEST FOR END OF PATTERN
0102 05140         B     P0314
0103 05150         BCE   *+5,89,8
0104 05160         B     P0314
```

```
SEQ  PGLIN LABEL   OPCD  OPERAND                                    A/C V1-M13

0105 05170 P0517   PCB   BEGIN                  PUNCH COLUMN BINARY
0106 05180 *                                     EOJ HALT
0107 05190 P0519   WCP   EOJ
0108 05200         H     999,999
0109 06010 P0601   WCP   1                      DATA CARD ERROR
0110 06020         B     BEGIN
0111 06030  EOJ    DCW   'END OF JOB -- REMOVE ANY CORRECTIONS TYPED ON'
0112 06040               ' CONSOLE'
0113 06050 GM      DCW   ' '
0114 07000 *                                     DOUBLED ROW OPTION
0115 07010 P0701   BCE   P0711,0+X1,0           TEST FOR ZERO
0116 07020         BCE   P0714,0+X1,1                    ONE
0117 07030         BCE   P0717,0+X1,2                    TWO
0118 07040         BCE   P0720,0+X1,3                    THREE
0119 07050         BCE   P0803,0+X1,4                    FOUR
0120 07060         BCE   P0806,0+X1,5                    FIVE
0121 07070         BCE   P0811,0+X1,6                    SIX
0122 07080         BCE   P0814,0+X1,7                    SEVEN
0123 07090         B     P0601                 DATA ERROR
0124 07100 *                                    BUILD DOUBLED BINARY COLUMN
0125 07110 P0711   MLC   '  ',401+X2           ZERO (NO BITS)
0126 07120         MLC   '  ',501+X2
0127 07130         B     P0818
0128 07140 P0714   MLNS  '1',500+X2             ONE (1-BIT)
0129 07150         MLNS  '1',501+X2
0130 07160         B     P0818
0131 07170 P0717   MLNS  '3',500+X2             TWO (1,2-BITS)
0132 07180         MLNS  '3',501+X2
0133 07190         B     P0818
0134 07200 P0720   MLNS  '7',500+X2             THREE (1,2,4-BITS)
0135 08010         MLNS  '7',501+X2
0136 08020         B     P0818
0137 08030 P0803   MLNS  GM,500+X2              FOUR (1,2,4,8-BITS)
0138 08040         MLNS  GM,501+X2
0139 08050         B     P0818
0140 08060 P0806   MLNS  GM,500+X2              FIVE (1,2,4,8,A-BITS)
0141 08070         MLZS  'Z',500+X2
0142 08080         MLNS  GM,501+X2
0143 08090         MLZS  'Z',501+X2
0144 08100         B     P0818
0145 08110 P0811   MLC   GM,500+X2              SIX  (1,2,4,8,A,B-BITS)
0146 08120         MLC   GM,501+X2
0147 08130         B     P0818
0148 08140 P0814   MLC   GM,500+X2              SEVEN (1,2,4,8,A,B,1-BITS)
0149 08150         MLC   GM,501+X2
0150 08160         MLNS  '1',400+X2
0151 08170         MLNS  '1',401+X2
0152 08180 P0818   SBR   X1,1+X1
0153 08190         SBR   X2,2+X2
0154 08200         BCE   P0601,93,8
0155 08210         BCE   *+5,88,6
0156 08220         B     P0314
```

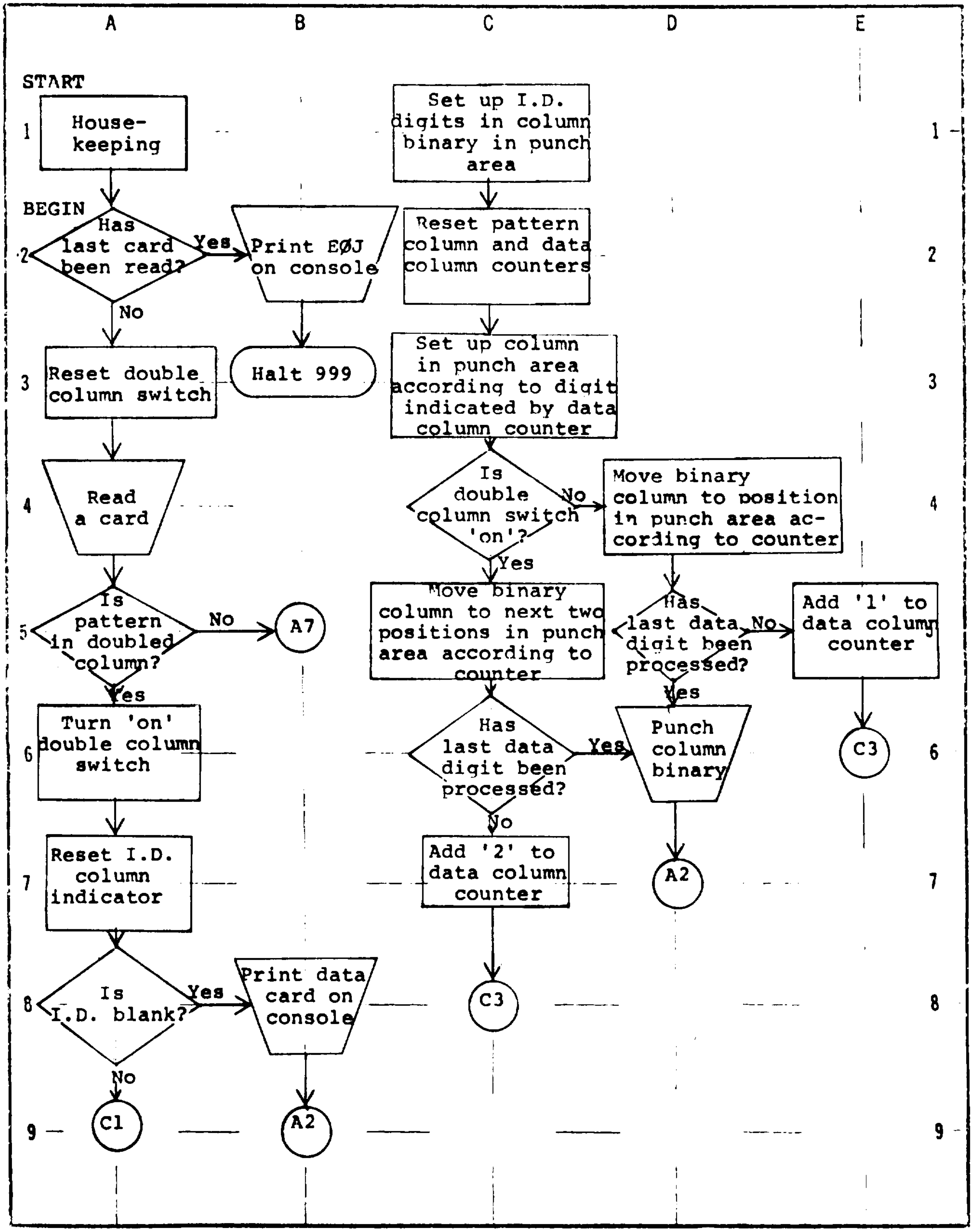
```
SEQ  PGLIN LABEL   OPCD  OPERAND                                        A/C V1-M13

0157 08230         BCE   P0517,89,8
0158 09010         B     P0314
0159 09020         END   START
0160               LTRL  '8'
0161               LTRL  '4'
0162               LTRL  '2'
0163               LTRL  '1'
0164               LTRL  'J'
0165               LTRL  'Z'
0166               LTRL  ' '
0167               LTRL  '3'
0168               LTRL  '7'
0169               LTRL  '  '
                             END OF LISTING
```

TEXAS CHRISTIAN UNIVERSITY
COMPUTER CENTER

DATE September 26 PROGRAM PAT

ROUTINE PAGE 1 of 1



TCU-CCFORM-CS315

I. Identification

1. Program Name: VARGUS 9
2. Category: Pattern Generation
3. Purpose: To compute patterns by producing probabilistic variations on a prototype.
4. Date: January, 1966
5. Programmer: Selby Evans

II. Use Information

1. Language: 1800 Basic FØRTRAN IV.
2. Machine: IBM 1800, 32K, 16-bit words.
3. Limitations: Up to 32 columns in a pattern.
4. Input data:

   The initial call to RANDY causes a START card to be read by the subroutine. See RANDY documentation for details.

   NCOL: Number of columns in a pattern, NCØL less than or equal to 32.

   NSCHM: The schema identification number. Typically it is 3 or 4 digits ending in 00.

   NINST: The number of patterns to be generated. NINST less than or equal to 99.

   MAX: A vector the first NCØL elements of which form the schema.

P: The probability matrix the I-th column of which controls the frequency distribution (dispersion) of the I-th elements of the patterns about the I-th schema element. NCØL such probability vectors are read in; i.e., one for each element of the schema.

5. Output Data:

NPAT: The individual pattern identification number.

INST: The pattern itself.

PR: The cumulative product of the probability of each actual selection in constructing a pattern.

FMS: The mean squared deviation of each pattern from its schema (elsewhere called pattern variance).

6. Subroutines Required:

RANDY: A pseudo-random number generator.

III. Mathematical Method and References

Evans, S. H., and Mueller, M. VARGUS 9: Computed patterns for schema research. Psychonomic Science, 1966, 12, 511-512.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
// JOB               11000    30 JUN 71 13.369 HRS
// * U-2050-003
// FOR ABBA    30 JUN 71 13.370 HRS
*NONPROCESS PROGRAM
*IOCS (CARD,1443 PRINTER,PLOTTER,DISK,MAGNETIC TAPE,KEYBOARD,TYPEWRITER)
*ONE WORD INTEGERS
*LIST ALL
C     VARGUS 9
      DIMENSION P(9,32),MAX(32),INST(32)
      CALL RANDY(R)
      WRITE(3,901)
  901 FORMAT('1',T19,'SAMPLE VARGUS NINE PATTERNS')
      WRITE(3,911)
  911 FORMAT('0',T6,'ID',T26,'PATTERN',T48,'PROB.',T55,'PATTERN VARIANCE
     1',/)
C
C     READ PARAMETERS
      READ(2,1) NCOL,NSCHM,NINST
1     FORMAT(5I5)
      DO 101 IN=1,32
      MAX(IN)=0
101   INST(IN)=0
C
C     READ PROBABILITY MATRIX
      DO 55 J=1,NCOL
   55 READ(2,2) MAX(J),(P(I,J),I=1,9)
2     FORMAT(I5,3X,9F8.4)
C
      FNCOL =NCOL
C
C     OUTPUT SCHEMA
      WRITE(3,5) NSCHM,(MAX(I),I=1,NCOL)
5     FORMAT(3X,I5,8X,32I2)
C
C     SET UP INSTANCE LOOP
      DO 99 IN=1,NINST
      FMS=0
      PR=1.0
      SS=0
C
C     SET UP COLUMN LOOP
      DO 89 ICOL=1, NCOL
      CALL RANDY(R)
C     CHOOSE ELEMENT
      DO 79 L=1,9
      R = R - P(L,ICOL)
      IF(R)80,79,79
79    CONTINUE
      L=9
80    CONTINUE
      PR=PR* P(L,ICOL)
      T= MAX(ICOL)-L
      SS = SS + T*T
89    INST(ICOL)=L
```

```
C      END INSTANCE LOOP
       NPAT= NSCHM + IN
       FMS = SS/FNCOL
       WRITE(3,15) NPAT,(INST(I),I=1,NCOL),PR,FMS
15     FORMAT(3X,I5,8X,14I2,2F8.4)
99     CONTINUE
       CALL EXIT
       END

VARIABLE ALLOCATIONS
     P(R )=023E-0000        R(R )=0240        FNCOL(R )=0242          FMS(R )=0244
     T(R )=024A          MAX(I )=026B-024C   INST(I )=028B-026C   NCOL(I )=028C
    IN(I )=028F             J(I )=0290            I(I )=0291         ICOL(I )=0292

STATEMENT ALLOCATIONS
 901   =02A0  911   =02B3  1     =02CF   2     =02D2  5     =02D7  15    =02DD   10
 89    =03BE  99    =03F6

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS
 IOCS

CALLED SUBPROGRAMS
 RANDY   FADD    FSUBX   FMPY    FMPYX   FDIV    FLD     FSTO    FLOAT   IS
 MIOIX   MIOF    MIOI    SUBSC   FCHRI   TYPEN   HOLEB   MAGT    PRNTN   EB

REAL CONSTANTS
  .100000E 01=0298

INTEGER CONSTANTS
     3=029A       2=029B       1=029C       32=029D       0=029E       9=029F

CORE REQUIREMENTS FOR ABBA
 COMMON        0  INSKEL COMMON        0
  VARIABLES     664   PROGRAM     362


END OF COMPILATION
```

SAMPLE VARGUS NINE PATTERNS

ID	PATTERN	PROB.	PATTERN VARIANCE
2000	4 3 5 7 4 6 5 4 5 6 5 5 7 5		
2001	4 3 5 7 4 6 5 4 5 6 5 5 5 3	0.0000	0.5714
2002	4 3 5 7 2 6 5 4 5 7 5 5 7 5	0.0001	0.3571
2003	2 3 5 7 4 6 5 3 5 6 5 4 7 5	0.0000	0.4285
2004	4 3 5 7 4 6 5 4 5 6 6 5 7 5	0.0055	0.0714
2005	4 3 6 8 4 6 5 4 5 6 5 5 9 3	0.0000	0.7142
2006	4 3 5 7 4 6 5 4 5 6 5 5 7 5	0.0870	0.0000
2007	4 3 5 7 3 6 5 4 5 6 5 5 7 5	0.0055	0.0714
2008	4 3 5 7 5 6 4 4 5 6 5 5 7 5	0.0003	0.1428
2009	4 3 4 7 6 6 5 4 6 6 5 5 7 5	0.0000	0.4285
2010	4 3 5 7 4 6 5 4 5 6 5 5 7 4	0.0055	0.0714

I. Identification

1. Program Name: VARG 9
2. Category: Pattern Generation
3. Purpose: Compute VARGUS 9 patterns and print dots that can be connected to form a serriform VARGUS 9 pattern.
4. Date: April, 1970
5. Programmer: David R. Harris

II. Use Information

1. Language: 1800 Basic FORTRAN IV.
2. Machine: IBM 1800, 32K, 16-bit words.
3. Limitations: Maximum of 32 element patterns.
4. Input Data:

First call to subroutine RANDY causes START card to be read. See RANDY documentation for details.

IMØ: Month.

IDS: Day.

IYR: Year.

USER: User information; e.g., name.

NCØL: Number of digits per pattern.

NSHEM: Identification number of schema. Should be 3 digits at most.

NINST: The number of patterns desired.

MAX: A vector the first NCØL elements of which contain the schema.

PRØB: A probability matrix the I-th column of which contains probabilities which control the frequency distribution of values of the I-th element in the patterns produced. For example if MAX(I) is a 5, then the column PROB (1,I) to PROB (32,I) might be 0,0,0.1, 0.1, 0.6, 0.1, 0.1, 0,0,0, etc.

5. Output Data:

ARY: A matrix containing alphameric blanks and points. The points may be connected to form a serriform pattern.

NPAT: Pattern identification number.

INST: The vector of digits which constitute the basic pattern.

PR: A cumulative product of probabilities of the elements actually chosen.

FMS: The mean square deviations of the pattern from its prototype. Also called pattern variance.

All output to logical unit 8 is to produce a tape (in binary) utilized by program DVAR.

6. Subroutines Required:

RANDY: A pseudo-random number generator.

III. Mathematical Methods and References

Evans, S. H. and Mueller, M. VARGUS 9: Computed stimuli for schema research. Psychonomic Science, 1966, 12, 511-512.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
// JOB                  11000    30 JUN 71  13.512 HRS
// * U-2050-003
// FOR VARG    30 JUN 71  13.513 HRS
*LIST ALL
*IOCS (CARD,1443 PRINTER, DISK,PLOTTER,MAGNETIC TAPE)
*ONE WORD INTEGERS
*NONPROCESS PROGRAM
C     VARG 9
      DIMENSION PROB (9,32), MAX(32), INST(32), USER(3)
      DIMENSION ARY(20,32)
      DATA POINT, BLANK /'.', ' '/
C
      RR = 1.
      CALL RANDY(RR)
    1 FORMAT (3I5)
    2 FORMAT (I5,3X    ,9F8.5)
    3 FORMAT (3I3,3A4)
    4 FORMAT (9H1VARGUS 9, 3I3, 3A4, 4X, 6HSCHEMA, I5, 1H.,I5, 5H INST)
    5 FORMAT (6H0 VR9 ,       I4, 1H, 8(1H ,4I1))
    6 FORMAT (6H0 VR9 ,       I4, 1H, 8(1H ,4I1)/ E14.8, F12.5)
    7 FORMAT (1H1)
    8 FORMAT (50X, 14A3//)
    9 FORMAT (////////)
      REWIND 8
C
C     READ DATA AND USER
 8000 READ (2,3) IMO, IDA, IYR, (USER(I), I=1,3)
C     READ PARAMETERS
      READ (2,1) NCOL, NSHEM, NINST
      DO 101 IN=1,32
      MAX(IN)=0
  101 INST(IN)=0
C
C     READ PROBABILITY MATRIX
      READ (2,2)  (MAX(J), (PROB(I,J), I=1,9), J=1,NCOL)
C
      FNCOL=NCOL
C     OUTPUT IDENTIFICATION
      WRITE (3,4) IMO, IDA, IYR, (USER(I), I=1,3), NSHEM, NINST
      WRITE (8) IMO, IDA, IYR, USER
      WRITE (8) NCOL, NSHEM, NINST
C     OUTPUT SCHEMA
      WRITE (3,5) NSHEM, (MAX(I), I=1,NCOL)
      WRITE (8) NSHEM, (MAX(I), I=1,NCOL)
      DO 10  I=1,20
      DO 10  J=1,32
   10 ARY(I,J)=BLANK
      IP=10
      ARY(IP,1)=POINT
      ARY(IP,NCOL)=POINT
      DO 15  I=1,NCOL
      II=10-MAX(I)
   15 ARY(II,I)=POINT
      WRITE (3,9)
```

```
      WRITE (3,8) ((ARY(I,J), J=1,14), I=1,IP)
      WRITE (3,7)
C     SET INSTANCE LOOP
      DO 99 IN=1,NINST
      PR=1.0
      SS=0.0
      DO 20  I=1,20
      DO 20  J=1,32
   20 ARY(I,J)=BLANK
      ARY(IP,NCOL)=POINT
      ARY(IP,1)=POINT
C
C     SET COLUMN LOOP
      DO 89 ICOL=1,NCOL
      CALL RANDY(RR)
      R = RR
C     CHOSE ELEMENT
      DO 79 L=1,9
      R=R-PROB(L,ICOL)
      IF(R)80,79,79
   79 CONTINUE
      L=9
   80 CONTINUE
      PR=PR*PROB(L,ICOL)
      T=MAX(ICOL)-L
      SS=SS+(T*T)
   89 INST(ICOL)=L
      NPAT = NSHEM+IN
      FMS=SS/FNCOL
      WRITE (3,6) NPAT, (INST(I), I=1,32  ),  PR, FMS
      WRITE (8) NPAT, (INST(I), I=1,NCOL), PR, FMS
      DO 30  J=1,NCOL
      II=10-INST(J)
   30 ARY(II,J)=POINT
      WRITE (3,9)
      WRITE (3,8) ((ARY(I,J), J=1,14), I=1,IP)
      WRITE (3,7)
   99 CONTINUE
C     END INSTANCE LOOP
      CALL EXIT
      END

VARIABLE ALLOCATIONS
  PROB(R )=023E-0000  USER(R )=0244-0240   ARY(R )=0744-0246     RR(R )=0746
 POINT(R )=074C          PR(R )=074E        SS(R )=0750           R(R )=0752
   MAX(I )=0777-0758  INST(I )=0797-0778   IMO(I )=0798         IDA(I )=0799
  NCOL(I )=079C      NSHEM(I )=079D      NINST(I )=079E          IN(I )=079F
    II(I )=07A2       ICOL(I )=07A3          L(I )=07A4        NPAT(I )=07A5

UNREFERENCED STATEMENTS
```

```
8000

STATEMENT ALLOCATIONS
 1    =07B6  2     =07B9  3     =07BE  4     =07C3  5     =07DB  6     =07E9  7
 101  =0848  10    =08F7  15    =0938  20    =0990  79    =09E2  80    =09EF  89

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS
 IOCS

CALLED SUBPROGRAMS
 RANDY  FADD   FSUBX  FMPY   FMPYX  FDIV   FLD    FSTO   FSTOX  FL(
 MWRT   MCOMP  MIOFX  MIOIX  MIOF   MIOI   SUBSC  REWND  UIOAF  UI(
 PRNTN  EBPRT  CARDN

REAL CONSTANTS
 .100000E 01=07A8    .000000E 00=07AA

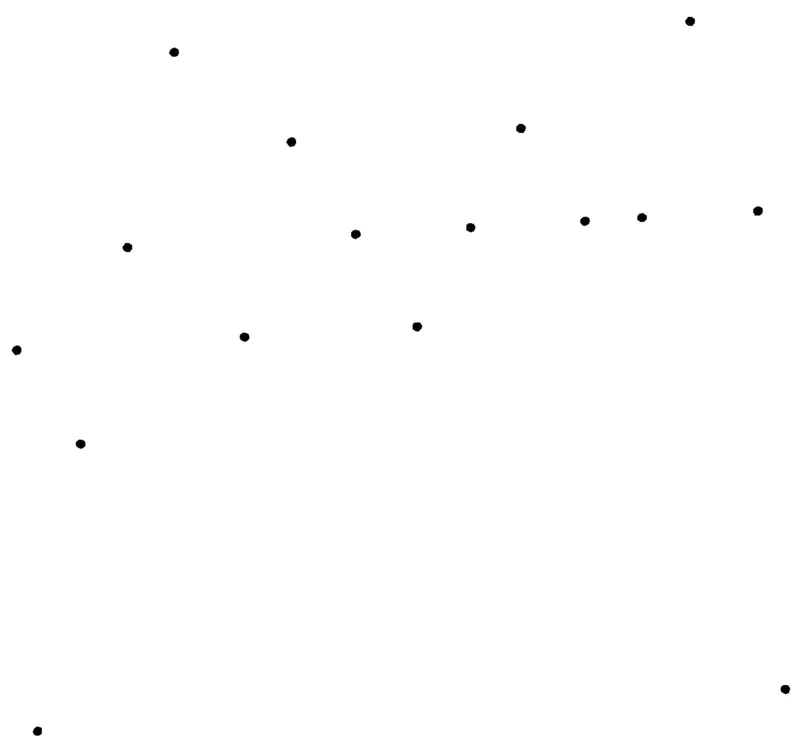
INTEGER CONSTANTS
     8=07AC      2=07AD      1=07AE      3=07AF      32=07B0      0=07B1

CORE REQUIREMENTS FOR VARG
 COMMON       0  INSKEL COMMON      0
  VARIABLES    1960  PROGRAM     792


END OF COMPILATION
```

VARGUS 9 5 26 71 I.S.C.S. SCHEMA 2000, 30 INST

VR9 2000, 4357 4654 5655 75



VR9 2004, 4357 4654 5665 7500 0000 0000 0000 0000

.55253123E-02   0.07142

I. Identification

1. Program Name: DVAR

2. Category: Pattern Measurement and Description

3. Purpose: Finds Pythagorean distances of a set of patterns from a given pattern.

4. Date: April, 1970

5. Programmer: David R. Harris

II. Use Information

1. Language: 1800 Basic FORTRAN IV.

2. Machine: IBM 1800, 32K, 16-bit words.

3. Limitations: The distance of each pattern in a set may be found from up to 4 defined patterns.

4. Input data:

   Tape produced by program VARG 9.

   TITLE: Distance values against which to compare computed distances and thereby form a histogram.

   NPRØT: Number of schema patterns: up to four.

5. Output data:

   NPAT: Pattern identification number.

   DIST: Distance of a pattern from the set from NPRØT given patterns.

   AVER: Average pattern variance; i.e., average of FMS values.

ARY: Histogram of dots.

TITLE: Abscissa of the histogram.

IFREQ: A frequency count of the dots printed over each abscissa value.

NØS: Histogram corresponding to ARY but constructed from actual pattern numbers not dots.

6. Subroutines Required:

None.

III. Mathematical Methods and References

Evans, S. H. and Mueller, M. VARGUS 9: Computed stimuli for schema research. Psychonomic Science, 1966, 12, 511-512.

Rankin, W. C., Markley, R. P., and Evans, S. H. Pythagorean distance and the judged similarity of schematic stimuli. Perception and Psychophysics, 1970, 7, 103-107.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
// JOB    30 JUN 71 13.650 HRS
// * U-2050-003
// FOR DVAR    30 JUN 71 13.650 HRS
*LIST ALL
*IOCS (CARD,1443 PRINTER, DISK,PLOTTER,MAGNETIC TAPE)
*ONE WORD INTEGERS
*NONPROCESS PROGRAM
C    DVAR
      DIMENSION USER(3), MAX(32), INST(32), ARY(24,16), IFREQ(24),
     1 TITLE(24), NOS(24,16), NPONT(24), NPROT(14,4), DIST(4)
      DATA POINT, BLANK /'.', ' '/
    1 FORMAT(9H1VARGUS 9, 3I3,3A4,4X,6HSCHEMA,I5,1H,,I5,5H INST)
    2 FORMAT(13H AVERAGE PV = ,F12.5)
    3 FORMAT(24A5)
    4 FORMAT(1H0,I4,23I5)
    5 FORMAT(1X,F4.2,23F5.2//)
    6 FORMAT(8F10.5)
7     FORMAT(5X,4(10X,14I1))
    8 FORMAT(I5,4(10X,F14.5))
    9 FORMAT(4(5X,14I1))
   10 FORMAT(I5,4F15.5)
      REWIND 8
C
      READ(2,6) TITLE
      READ(2,9) NPROT
      READ(8) IMO,IDA,IYR,USER
      READ(8) NCOL,NSHEM,NINST
      WRITE(3,1) IMO,IDA,IYR,(USER(I),I=1,3),NSHEM,NINST
      WRITE(3,7) NPROT
      READ(8) NSHEM,(MAX(I),I=1,NCOL)
      DO 14 L=1,4
      TEMP=0.
      DO 13 KK=1,NCOL
      TEM=NPROT(KK,L)-MAX(KK)
   13 TEMP=TEMP+TEM*TEM
   14 DIST(L)=SQRT(TEMP)
      WRITE(3,8) NSHEM,DIST
C
      DO 20 I=1,24
      IFREQ(I)=0
      NPONT(I)=1
      DO 20 J=1,16
      NOS(I,J)=0
   20 ARY(I,J)=BLANK
C
      SUM=0.
      DO 50 I=1,NINST
      READ(8) NPAT,(INST(K),K=1,NCOL),PR,FMS
      SUM=SUM+FMS
      DO 16 L=1,4
      TEMP=0.
      DO 15 KK=1,NCOL
      TEM=NPROT(KK,L)-INST(KK)
   15 TEMP=TEMP+TEM*TEM
```

```
   16 DIST(L)=SQRT(TEMP)
      WRITE(3,8) NPAT,DIST
C
      DO 40 J=1,24
      IF(FMS-TITLE(J)) 30,30,40
   30 KK=NPONT(J)
      NOS(J,KK)=NPAT
      NPONT(J)=NPONT(J)+1
      IFREQ(J)=IFREQ(J)+1
      GO TO 50
   40 CONTINUE
   50 CONTINUE
      AVER=SUM/FLOAT(NINST)
      WRITE(3,2) AVER
      DO 70 I=1,24
      DO 70 J=1,16
      IF(IFREQ(I)-J) 70,60,60
   60 ARY(I,J)=POINT
   70 CONTINUE
      WRITE(3,3) ARY
      WRITE(3,5) TITLE
      WRITE (3,4) IFREQ
      IMAX=1
      DO 53 IB=1,24
      IF(IFREQ(IB)-IMAX) 53,52,52
   52 IMAX=IFREQ(IB)
   53 CONTINUE
      WRITE(3,865)
  865 FORMAT(1H1)
      DO 86 I=1,IMAX
      II=IMAX-I+1
   86 WRITE(3,4)(NOS(IX,II),IX=1,24)
      WRITE(3,5) TITLE
      WRITE(3,4) IFREQ
      CALL EXIT
      END

VARIABLE ALLOCATIONS
  USER(R )=0004-0000   ARY(R )=0304-0006 TITLE(R )=0334-0306  DIST(R )=033C-
 BLANK(R )=0342        SUM(R )=0344         PR(R )=0346        FMS(R )=0348
   MAX(I )=036D-034E  INST(I )=038D-036E IFREQ(I )=03A5-038E   NOS(I )=0525-
   IMO(I )=0576        IDA(I )=0577        IYR(I )=0578       NCOL(I )=0579
     I(I )=057C          L(I )=057D         KK(I )=057E          J(I )=057F
  IMAX(I )=0582         IB(I )=0583         II(I )=0584         IX(I )=0585

UNREFERENCED STATEMENTS
 10

STATEMENT ALLOCATIONS
 1     =0592  2     =05AA  3     =05B4  4     =05B7  5     =05BD  6     =05C4  7
```

```
865   =05DE   13    =0669   14    =067A   20    =06BA   15    =0724   16    =0735   30
70    =07C6   52    =0800   53    =0809   86    =0822

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS
 IOCS

CALLED SUBPROGRAMS
 FSQRT    FADD     FSUBX    FMPY     FLD      FSTO     FSTOX    FDVR     FLOAT    IS
 MCOMP    MIOAI    MIOAF    MIOFX    MIOIX    MIOF     MIOI     SUBSC    REWND    UI
 MAGT     PRNTN    EBPRT    CARDN

REAL CONSTANTS
  .000000E 00=0588

INTEGER CONSTANTS
     8=058A        2=058B        3=058C        1=058D        4=058E        24=058F

CORE REQUIREMENTS FOR DVAR
 COMMON         0   INSKEL COMMON       0
  VARIABLES    1416   PROGRAM     716


END OF COMPILATION
```

VARGUS 9 5 26 71 I.S.C.S. SCHEMA 2000. 30 INST

	43574654565575	45735334744365	47457436366455	45743737437635
2000	0.00000	7.21110	7.21110	7.93725
2001	2.82842	7.48331	7.21110	7.41619
2002	2.23606	8.06225	8.30662	8.36660
2003	2.44949	7.34846	7.74596	8.77496
2004	1.00000	7.41619	7.14142	7.74596
2005	3.16227	8.36660	8.71779	9.53939
2006	0.00000	7.21110	7.21110	7.93725
2007	1.00000	7.41619	7.68114	7.87400
2008	1.41421	6.92820	6.63325	7.93725
2009	2.44949	7.34846	6.92820	8.88819
2010	1.00000	7.28011	7.28011	8.00000
2011	2.64575	8.18535	8.66025	8.60232
2012	1.41421	7.21110	6.92820	8.18535
2013	3.46410	7.74596	9.38083	10.34408
2014	0.00000	7.21110	7.21110	7.93725
2015	1.73205	6.85565	7.14142	8.48528
2016	2.44949	8.36660	7.87400	9.32737
2017	0.00000	7.21110	7.21110	7.93725
2018	2.00000	7.61577	7.21110	7.81025
2019	2.00000	8.00000	7.74596	7.93725
2020	1.00000	6.70820	7.00000	7.61577
2021	1.73205	6.24499	6.85565	7.07106
2022	2.44949	7.48331	6.32455	7.28011
2023	1.73205	7.68114	7.00000	8.48528
2024	0.00000	7.21110	7.21110	7.93725
2025	2.00000	7.21110	6.63325	8.42615
2026	1.00000	6.70820	7.00000	7.61577
2027	0.00000	7.21110	7.21110	7.93725
2028	1.00000	7.00000	7.28011	7.61577
2029	1.41421	7.34846	7.48331	8.42615
2030	2.64575	7.00000	7.81025	8.71779

AVERAGE PV = 0.25238

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 .         .    .    .    .    .    .         .         .         .
 .         .    .    .    .         .
 .         .    .    .    .         .
 .         .                        .
 .         .                        .
           .                        .

0.00 0.07 0.14 0.21 0.28 0.35 0.42 0.50 0.57 0.64 0.71 0.78 0.85 0.92 1.00

 5    0    6    3    3    3    1    6    0    1    0    1    0    1    0
```

0	0	2028	0	0	0	0	2030	0	0	0	0	0	0	0
2027	0	2026	0	0	0	0	2022	0	0	0	0	0	0	0
2024	0	2020	0	0	0	0	2016	0	0	0	0	0	0	0
2017	0	2010	2029	2023	2025	0	2011	0	0	0	0	0	0	0
2014	0	2007	2012	2021	2019	0	2009	0	0	0	0	0	0	0
2006	0	2004	2008	2015	2018	2002	2003	0	2001	0	2005	0	2013	0
0.00	0.07	0.14	0.21	0.28	0.35	0.42	0.50	0.57	0.64	0.71	0.78	0.85	0.92	1.00
5	0	6	3	3	3	1	6	0	1	0	1	0	1	0

I. Identification

1. Program Name: VARGUS 10A

2. Category: Pattern Generator

3. Purpose: Input basic parameters, identification information, and matrices to be used in the generation of VARGUS 10-type patterns. See Subroutine JØIN for details of generation.

4. Date: July, 1968

5. Programmer: Chip Bruce

II. Use Information

1. Language: 1800 Basic FØRTRAN IV.

2. Machine: IBM 1800, 32K, 16-bit words.

3. Limitations: The final pattern matrix is a 48 x 48 matrix. Each of the corner and side submatrices are effectively 16 x 16, but each is represented internally by a string of subscript pairs not by a complete matrix. The first subscript of each pair is considered to be a row index and the second a column index. All corner matrices begin at (16, 10) and end at (10, 16). All side matrices begin at (10, 1) and end at (10, 16).

4. Input Data:

   a. A random-number generator START card under format (17I4,4I1). See subroutine RANDY documentation for further details about the START card.

   b. IDA, NØPAT (4I3). Day, month and year in numbers, followed by the number of patterns to be generated.

   c. NH, NL (2I3). Number of side matrices and number of corner matrices, respectively.

   d. MATH (25I3). This matrix contains in each row the side submatrices in subscript form. Four cards are required for each of the NH side submatrices. See Table in Remarks.

   e. MATL (25I3). This matrix contains in each row the corner submatrices in subscript form. Four cards are required for each of the NL corner submatrices.

5. Output Data: (To printer). See subroutine PATØT for details.

6. Subroutines Used: RANDY: A pseudo-random number generator.

   JØIN: Selects, positions and rotates side and corner matrices.

III. Mathematical Methods and References

Not Applicable.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

The following information is a list of the 40 side submatrices and 34 corner submatrices in subscript form. The side submatrices are identified by a leading H in the identification code and the corner submatrices by a leading L.

H1: (10,1) (9,1) (8,1) (7,2) (6,2) (5,3) (4,3) (3,3) (4,4) (4,5) (5,6) (5,7) (6,7) (6,8) (7,9) (7,10) (8,11) (8,12) (9,13) (9,14) (10,15) (10,16)

H2: (10,1) (9,1) (8,1) (7,2) (6,2) (5,3) (4,4) (3,4) (4,5) (5,5) (6,6) (7,6) (8,7) (9,7) (10,8) (11,8) (12,9) (13,9) (14,10) (15,11) (16,11) (16,12) (15,12) (15,11) (14,12) (13,13) (13,14) (12,14) (12,15) (11,15) (10,16)

H3: (10,1) (11,1) (11,2) (12,3) (12,4) (13,5) (14,5) (14,6) (15,7) (16,8) (16,9) (15,10) (15,11) (14,11) (14,12) (13,13) (13,14) (12,15) (11,16) (10,16)

H4: (10,1) (9,2) (9,3) (8,3) (8,4) (7,5) (6,6) (6,7) (5,8) (5,9) (4,9) (4,10) (3,11) (4,12) (5,13) (6,13) (7,14) (8,15) (9,15) (9,16) (10,16)

H5: (10,1) (10,2) (9,2) (8,2) (7,3) (6,4) (5,5) (4,6) (4,7) (3,8) (3,9) (3,10) (4,11) (4,12) (5,13) (6,13) (7,13) (8,13) (9,13) (10,14) (10,15) (10,16)

H6: (10,1) (10,2) (10,3) (11,4) (12,5) (12,6) (12,7) (12,8) (11,8) (10,8) (9,8) (9,9) (9,10) (9,11) (9,12) (9,13) (9,14) (9,15) (9,16) (10,16)

H7: (10,1) (11,1) (12,2) (13,3) (14,4) (14,5) (15,6) (15,7) (15,8) (15,9) (15,13) (15,11) (15,12) (14,13) (13,14) (12,15) (11,16) (10,16) (15,10)

H8: (10,1) (11,1) (12,2) (12,3) (13,3) (13,4) (14,5) (14,6) (15,7) (15,8) (15,9) (15,10) (15,11) (15,12) (15,13) (15,14) (14,15) (13,15) (13,16) (12,16) (11,16) (10,16)

H9: (10,1) (9,1) (8,1) (7,1) (6,2) (5,2) (5,3) (4,3) (4,4) (3,5) (3,6) (3,7) (3,8) (3,9) (4,10) (4,11) (5,12) (6,13) (7,14) (8,15) (9,15) (9,16) (10,16)

H10: (10,1) (9,1) (9,2) (8,3) (7,4) (7,5) (6,5) (6,6) (5,7) (5,8) (4,9) (4,10) (4,11) (4,12) (5,12) (6,12) (7,12) (8,12) (9,12) (10,11) (10,12) (10,13) (10,14) (10,15) (10,16)

H11: (10,1) (9,1) (9,2) (8,3) (8,4) (8,5) (7,6) (7,7) (7,8) (7,9) (7,10) (8,11) (8,12) (9,12) (9,13) (10,13) (11,14) (12,14) (13,14) (14,14) (13,15) (12,15) (12,16) (11,16) (10,16)

H12: (10,1) (9,2) (9,3) (9,4) (9,5) (9,6) (9,7) (8,8) (8,9) (8,10) (8,11) (8,12) (8,13) (8,14) (8,15) (9,15) (10,15) (10,16)

H13: (10,1) (9,2) (8,3) (8,4) (7,4) (7,5) (6,6) (6,7) (5,7) (5,8) (5,9) (5,10) (6,10) (7,11) (8,11) (8,12) (8,13) (9,13) (9,14) (10,14) (10,15) (10,16)

H14: (10,1) (11,2) (12,3) (13,4) (14,4) (15,5) (15,6) (15,7) (15,8) (15,9) (15,10) (15,11) (14,12) (14,13) (14,14) (13,14) (12,14) (12,15) (11,15) (10,16)

H15: (10,1) (10,2) (10,3) (10,4) (10,5) (10,6) (10,7) (10,8) (10,9) (10,10) (10,11) (10,12) (10,13) (10,14) (10,15) (10,16)

H16: (10,2) (11,2) (12,3) (13,4) (13,5) (14,6) (14,7) (15,8) (15,9) (15,10) (15,11) (14,12) (14,13) (13,14) (12,14) (11,15) (10,15) (10,16) (10,1)

H17: (10,1) (10,2) (11,2) (12,2) (13,3) (14,4) (15,5) (16,6) (15,7) (14,8) (13,9) (13,10) (12,11) (12,12) (11,13) (11,14) (10,15) (10,16)

H18: (10,1) (10,2) (9,2) (8,2) (7,3) (7,4) (6,5) (6,6) (6,7) (6,8) (6,9) (6,10) (6,11) (6,12) (7,13) (8,14) (9,15) (10,15) (10,16)

H19: (10,1) (10,2) (11,2) (12,3) (13,4) (13,5) (14,6) (14,7)
(14,8) (14,9) (13,10) (12,11) (11,11) (10,12) (10,13)
(10,14) (10,15) (10,16)

H20: (10,1) (10,2) (9,2) (8,2) (7,3) (7,4) (7,5) (7,6) (7,7)
(7,8) (8,9) (8,10) (9,11) (9,12) (10,13) (10,14) (10,15)
(10,16)

H21: (10,1) (10,2) (10,3) (10,4) (10,5) (10,6) (9,6) (8,6)
(7,7) (6,7) (6,8) (6,9) (6,10) (6,11) (6,12) (6,13)
(6,14) (7,14) (8,14) (9,14) (10,14) (10,15) (10,16)

H22: (10,1) (10,2) (11,2) (12,2) (13,2) (14,2) (15,3) (16,4)
(16,5) (16,6) (16,7) (16,8) (16,9) (16,10) (16,11)
(16,12) (16,13) (15,14) (14,15) (13,15) (12,15) (11,15)
(10,15) (10,16)

H23: (10,1) (10,2) (9,3) (9,4) (8,5) (7,5) (6,5) (5,5) (4,5)
(4,6) (4,7) (4,8) (4,9) (4,10) (3,11) (3,12) (3,13)
(4,13) (5,13) (6,13) (7,13) (8,13) (9,13) (10,13) (10,14)
(10,15) (10,16)

H24: (10,1) (10,2) (9,2) (8,2) (7,3) (6,3) (5,4) (5,5) (4,6)
(4,7) (4,8) (4,9) (4,10) (4,11) (6,12) (7,12) (8,11)
(5,12) (9,11) (9,12) (10,13) (10,14) (10,15) (10,16)

H25: (10,1) (10,2) (9,2) (9,3) (9,4) (9,5) (9,6) (9,7) (10,8)
(10,9) (11,10) (12,11) (12,13) (12,12) (11,14) (10,15)
(10,16)

H26: (10,1) (10,2) (9,3) (9,4) (9,5) (8,6) (8,7) (8,8) (7,9)
(7,10) (6,11) (6,12) (6,13) (6,14) (6,15) (7,15) (8,15)
(9,15) (10,15) (10,16)

H27: (10,1) (10,2) (9,2) (8,2) (7,2) (6,2) (5,3) (5,4) (6,5)
(6,6) (6,7) (7,8) (7,9) (6,10) (6,11) (6,12) (6,13)
(6,14) (7,15) (8,15) (9,14) (10,14) (10,15) (10,16)

H28: (10,1) (10,2) (9,2) (8,2) (7,2) (6,2) (5,3) (4,4) (5,5)
(6,6) (7,7) (8,7) (9,8) (10,9) (9,10) (9,11) (8,12)
(8,13) (8,14) (9,15) (10,15) (10,16)

H29: (10,1) (10,2) (11,2) (12,2) (13,2) (14,2) (15,3) (15,4)
(14,5) (14,6) (13,7) (13,8) (12,9) (12,10) (11,11) (11,12)
(10,13) (10,14) (9,15) (10,15) (10,16)

H30: (10,1) (10,2) (9,2) (8,2) (7,2) (7,3) (6,3) (5,4) (4,5)
(5,6) (5,7) (6,8) (6,9) (7,10) (8,11) (8,12) (9,13) (9,14)
(9,15) (10,15) (10,16)

H31: (10,1) (10,2) (9,2) (8,2) (7,2) (6,2) (5,3) (4,3) (4,4) (4,5) (4,6) (3,7) (3,8) (3,9) (3,10) (3,11) (3,12) (3,13) (3,14) (3,15) (4,15) (5,15) (6,15) (7,15) (8,15) (9,15) (10,15) (10,16)

H32: (10,1) (10,2) (11,2) (11,3) (12,4) (12,5) (13,6) (13,7) (14,8) (14,9) (14,10) (15,11) (15,12) (14,12) (13,12) (12,12) (11,13) (10,13) (9,13) (9,14) (10,15) (10,16)

H33: (10,1) (10,2) (9,3) (8,4) (10,5) (10,6) (10,7) (11,8) (12,9) (13,10) (14,11) (15,12) (14,13) (13,13) (12,14) (11,14) (10,15) (10,16) (9,4)

H34: (10,1) (10,2) (9,2) (8,2) (7,2) (6,3) (5,4) (5,5) (4,6) (4,7) (4,8) (4,9) (5,10) (5,11) (6,12) (7,13) (7,14) (8,14) (8,15) (9,15) (10,15) (10,16)

H35: (10,1) (10,2) (11,2) (12,3) (12,4) (13,5) (13,6) (14,7) (15,8) (15,9) (14,10) (13,11) (12,12) (11,12) (10,13) (10,14) (10,15) (10,16)

H36: (10,1) (10,2) (9,3) (9,4) (10,4) (11,4) (12,4) (13,4) (14,4) (15,4) (15,5) (15,6) (15,7) (15,8) (15,9) (15,10) (15,11) (15,12) (14,12) (13,12) (12,12) (11,12) (10,12) (10,13) (10,14) (10,15) (10,16)

H37: (10,1) (10,2) (11,2) (12,2) (13,2) (14,2) (13,3) (14,3) (15,4) (15,5) (15,6) (15,7) (15,8) (15,9) (15,10) (15,11) (15,12) (15,13) (15,14) (15,15) (14,15) (13,15) (12,15) (11,15) (10,15) (10,16)

H38: (10,1) (10,2) (9,3) (9,4) (9,5) (8,6) (8,7) (8,8) (8,9) (7,10) (7,11) (7,12) (7,13) (7,14) (6,15) (7,15) (8,15) (9,15) (10,15) (10,16)

H39: (10,1) (10,2) (9,3) (9,4) (9,5) (9,6) (9,7) (9,8) (9,9) (9,10) (9,11) (9,12) (9,13) (9,14) (9,15) (10,15) (10,16)

H40: (10,1) (10,2) (9,2) (8,2) (7,3) (6,3) (5,4) (5,5) (6,6) (7,7) (8,8) (9,8) (10,8) (9,9) (8,10) (7,11) (7,12) (8,13) (9,13) (10,14) (11,14) (10,15) (10,16)

L1: (16,10) (15,10) (14,10) (13,10) (12,10) (11,10) (10,10) (9,10) (8,10) (7,10) (6,10) (5,11) (4,12) (4,13) (4,14) (5,15) (6,15) (7,15) (8,15) (9,15) (10,15) (10,16)

L2: (16,10) (16,9) (15,8) (15,7) (14,6) (13,5) (12,4) (11,4) (10,3) (9,3) (8,3) (7,3) (6,4) (5,4) (4,5) (4,6) (3,7) (3,8) (3,9) (3,10) (3,11) (4,12) (5,13) (6,14) (7,15) (8,16) (9,16) (10,16)

L3: (16,10) (15,11) (14,11) (13,11) (12,10) (12,9) (12,8) (12,7) (12,6) (12,5) (12,4) (11,4) (10,4) (9,4) (8,4) (7,4) (6,4) (5,4) (4,4) (4,5) (4,6) (4,7) (4,8) (4,9) (4,10) (4,11) (4,12) (4,13) (4,14) (4,15) (5,15) (6,15) (7,15) (8,15) (9,15) (10,15) (10,16)

L4: (16,10) (16,9) (15,8) (15,7) (15,6) (15,5) (15,4) (14,4) (13,4) (12,4) (11,4) (10,4) (9,3) (8,3) (7,3) (6,3) (5,3) (4,3) (4,4) (4,5) (4,6) (4,7) (4,8) (4,9) (4,10) (4,11) (4,12) (4,13) (4,14) (4,15) (5,15) (6,15) (7,15) (8,15) (9,16) (10,16)

L5: (16,10) (16,11) (16,12) (16,13) (15,13) (15,14) (14,15) (13,15) (13,16) (12,16) (11,16) (10,16)

L6: (16,10) (16,9) (15,8) (14,7) (13,6) (12,5) (12,4) (11,3) (10,4) (9,5) (8,6) (7,6) (6,7) (5,8) (4,9) (3,10) (4,11) (5,12) (6,13) (6,14) (7,15) (8,16) (9,16) (10,16)

L7: (16,10) (15,9) (15,10) (15,8) (15,7) (15,6) (14,5) (13,5) (12,5) (11,5) (10,5) (9,5) (9,6) (8,6) (7,6) (7,7) (6,7) (5,8) (5,9) (4,10) (4,11) (4,12) (4,13) (4,14) (4,15) (5,15) (5,16) (6,16) (7,16) (8,16) (9,16) (10,16)

L8: (16,10) (16,9) (16,8) (16,7) (15,6) (15,5) (15,4) (14,4) (13,3) (12,3) (11,3) (10,3) (9,3) (8,3) (7,3) (6,3) (5,4) (4,4) (4,5) (4,6) (3,7) (3,8) (3,9) (3,10) (3,11) (3,12) (3,13) (3,14) (4,15) (5,15) (6,15) (7,15) (8,15) (9,15) (10,16)

L9: (16,10) (15,11) (14,11) (13,12) (12,12) (11,13) (10,14) (10,15) (10,16)

L10: (16,10) (15,10) (14,10) (13,10) (12,10) (11,10) (11,11) (11,12) (10,13) (10,14) (10,15) (10,16)

L11: (16,10) (15,10) (14,11) (13,11) (12,12) (11,13) (11,14) (11,15) (10,16)

L12: (16,10) (15,9) (14,9) (13,9) (12,9) (11,8) (10,8) (9,8) (8,7) (7,7) (7,8) (7,9) (6,10) (6,11) (6,12) (6,13) (6,14) (6,15) (6,16) (7,16) (8,16) (9,16) (10,16)

L13: (16,10) (15,10) (14,10) (13,10) (12,10) (12,9) (12,8)
(12,7) (12,6) (12,5) (12,4) (11,4) (10,4) (9,4) (8,4)
(7,4) (6,4) (5,4) (4,4) (4,5) (4,6) (4,7) (4,8) (4,9)
(4,10) (4,11) (4,12) (4,13) (4,14) (6,15) (5,15) (7,14)
(8,14) (9,14) (10,14) (10,15) (10,16)

L14: (16,10) (15,11) (14,12) (13,12) (12,13) (11,14) (11,15)
(10,16)

L15: (16,10) (16,11) (15,12) (14,12) (13,13) (12,13) (11,13)
(10,13) (9,13) (9,14) (9,15) (10,16)

L16: (16,10) (15,10) (14,10) (13,10) (12,10) (11,10) (10,10)
(9,10) (8,10) (7,10) (6,10) (5,11) (5,12) (5,13) (4,14)
(5,15) (6,15) (7,15) (8,15) (9,15) (10,15) (10,16)

L17: (16,10) (15,10) (15,9) (15,8) (15,7) (15,6) (15,5) (15,4)
(14,3) (13,3) (12,3) (11,3) (10,3) (9,3) (8,3) (7,3)
(6,3) (5,3) (4,4) (4,5) (4,6) (4,7) (5,8) (5,9) (5,10)
(5,11) (5,12) (6,12) (7,12) (8,12) (9,12) (10,12) (11,12)
(11,13) (11,14) (10,15) (10,16)

L18: (16,10) (16,11) (15,11) (15,12) (14,13) (14,14) (14,15)
(13,15) (12,15) (11,14) (10,14) (10,15) (10,16)

L19: (16,10) (16,9) (16,8) (15,7) (14,6) (13,5) (12,5) (11,4)
(10,4) (9,5) (8,5) (7,6) (6,7) (6,8) (5,9) (5,10) (5,11)
(6,12) (6,13) (7,14) (8,15) (9,16) (10,16)

L20: (16,10) (15,9) (15,8) (14,8) (13,8) (12,8) (11,8) (10,8)
(9,9) (8,10) (8,11) (8,12) (8,13) (8,14) (9,14) (10,14)
(10,15) (10,16)

L21: (16,10) (15,10) (14,10) (13,10) (12,10) (11,10) (10,10)
(9,11) (9,12) (9,13) (9,14) (10,15) (10,16)

L22: (16,10) (16,11) (16,12) (15,13) (15,14) (14,14) (13,14)
(12,15) (11,15) (10,16)

L23: (16,10) (15,9) (14,8) (13,7) (12,7) (11,6) (10,6) (9,6)
(8,6) (7,7) (7,8) (7,9) (7,10) (7,11) (7,12) (7,13)
(8,14) (9,15) (10,16)

L24: (16,10) (15,11) (14,12) (14,13) (13,14) (13,15) (12,15)
(11,16) (10,16)

L25: (16,10) (16,9) (15,8) (14,7) (13,6) (12,6) (11,6) (10,6)
(9,6) (8,7) (7,7) (6,8) (6,9) (5,10) (5,11) (5,12) (5,13)
(6,14) (7,15) (8,16) (9,16) (10,16)

L26: (16,10) (15,9) (14,9) (13,8) (12,8) (11,8) (10,7) (9,7)
(8,8) (7,9) (6,10) (6,11) (5,12) (5,13) (6,14) (7,15)
(8,16) (9,16) (10,16)

L27: (16,10) (15,10) (14,10) (13,9) (12,9) (11,9) (10,9) (9,9)
(8,9) (7,10) (7,11) (7,12) (6,13) (6,14) (7,15) (8,16)
(9,16) (10,16)

L28: (16,10) (15,10) (14,10) (13,11) (13,12) (11,12) (11,13)
(10,14) (10,15) (10,16) (12,12)

L29: (16,10) (15,10) (14,10) (13,10) (12,10) (11,10) (10,10)
(10,9) (10,8) (10,7) (10,6) (10,5) (10,4) (10,3) (9,3)
(8,3) (7,3) (6,3) (6,4) (6,5) (6,6) (6,7) (5,7) (4,7)
(4,8) (4,9) (4,10) (4,11) (4,12) (4,13) (4,14) (4,15)
(4,16) (5,15) (6,15) (7,15) (8,15) (9,15) (10,15) (10,16)

L30: (16,10) (16,9) (16,8) (15,7) (14,6) (13,5) (12,5) (11,4)
(10,4) (9,4) (8,4) (7,5) (6,5) (5,6) (5,7) (5,8) (5,9)
(6,10) (7,11) (8,11) (9,12) (10,12) (11,12) (9,13) (8,14)
(9,15) (10,16)

L31: (16,10) (15,9) (14,9) (13,8) (12,8) (11,8) (10,7) (9,7)
(8,7) (7,8) (6,9) (7,10) (8,11) (9,11) (9,12) (9,13)
(9,14) (9,15) (10,16)

L32: (16,10) (16,9) (15,8) (14,7) (13,8) (13,9) (12,10) (11,10)
(10,9) (9,8) (8,7) (7,8) (6,9) (5,10) (4,11) (5,12) (6,12)
(7,14) (8,15) (9,16) (10,16) (7,13)

L33: (16,10) (15,10) (14,11) (13,11) (12,12) (11,12) (10,12)
(9,12) (8,13) (9,14) (9,15) (10,16)

L34: (16,10) (15,10) (14,10) (13,10) (12,10) (11,10) (11,11)
(11,12) (11,13) (11,14) (11,15) (10,16)

```
// JOB                 11000    30 JUN 71 13.695 HRS
// * U-2050-003
// FOR VAR10    30 JUN 71 13.696 HRS
*NON PROCESS PROGRAM
*IOCS(CARD,1443 PRINTER)
*ONE WORD INTEGERS
*LIST ALL
C   VARGUS 10-A
C
C      CHIP BRUCE
C
C      INSTITUTE FOR THE STUDY OF COGNITIVE SYSTEMS
C
C      VARGUS 10 A
C      AUGUST 1968
C
C      IBM 1800 MPX
C      1130 / 1800 BASIC FORTRAN IV
C      WITH SUBROUTINES RANDY, JOIN, AND PATOT
C
C      ACCEPTS NH H MATRICES AND NL L MATRICES
C      AND POSITIONS FOUR OF EACH TYPE, AFTER APPROPRIATE ROTATION,
C      IN A STANDARD 48 X 48 MATRIX, SO THAT A CONTINUOUS CLOSED FIGURE
C      IS FORMED
C
      INTEGER HORL(8)
      DIMENSION MATS (48, 48), MATH (50, 100), MATL (50, 100), IDA (3)
C
      CALL RANDY (R)
C
C      READ DATE AND NUMBER OF PATTERNS
      READ (2, 10) IDA, NOPAT
   10 FORMAT (4I3)
C
C      READ PARAMETERS
C      NH IS THE NUMBER OF H MATRICES
C      NL IS THE NUMBER OF L MATRICES
      READ (2, 20) NH, NL
   20 FORMAT (2I3)
C
C      READ H AND L TYPE SUBMATRICES
      READ (2, 30) ((MATH (I, J), J = 1, 100), I = 1, NH)
      READ (2, 30) ((MATL (I, J), J = 1, 100), I = 1, NL)
   30 FORMAT (25I3)
C
C      START LOOP OVER PATTERNS
      DO 150 NO = 1, NOPAT
C
C      PRINT HEADING
      WRITE (3, 120) NO, IDA
  120 FORMAT (11H1VARGUS 10A, 10X,14HPATTERN NUMBER, I3, 10X, 3I3)
C
      CALL JOIN (MATS, MATH, MATL, NH, NL,HORL)
      WRITE(3,145)(HORL(IXX),IXX=1,8)
```

```
  145 FORMAT ('0 L (1, 1)  H (1, 2)  L (1, 3)  H (2, 3)  L (3, 3)  H (3,
     1 2)  L (3, 1)  H (2, 1)' / I7, 7I10)
C
C      PRINT PATTERN
       CALL PATOT (MATS, 48, 48)
  150  CONTINUE
C
       CALL EXIT
       END

VARIABLE ALLOCATIONS
      R(R )=0000        MATS(I )=0901-0002  MATH(I )=1C89-0902  MATL(I )=3011-
  NOPAT(I )=301D          NH(I )=301E          NL(I )=301F           I(I )=3020
    IXX(I )=3023

STATEMENT ALLOCATIONS
 10   =302C  20   =302F  30   =3032  120  =3035  145  =304A  150  =3107

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS
 IOCS

CALLED SUBPROGRAMS
 RANDY   JOIN    PATOT   HRED    MWRT    MCOMP   MIOAI   MIOIX   MIOI    SUE

INTEGER CONSTANTS
     2=3026      1=3027     100=3028      3=3029      8=302A     48=302B

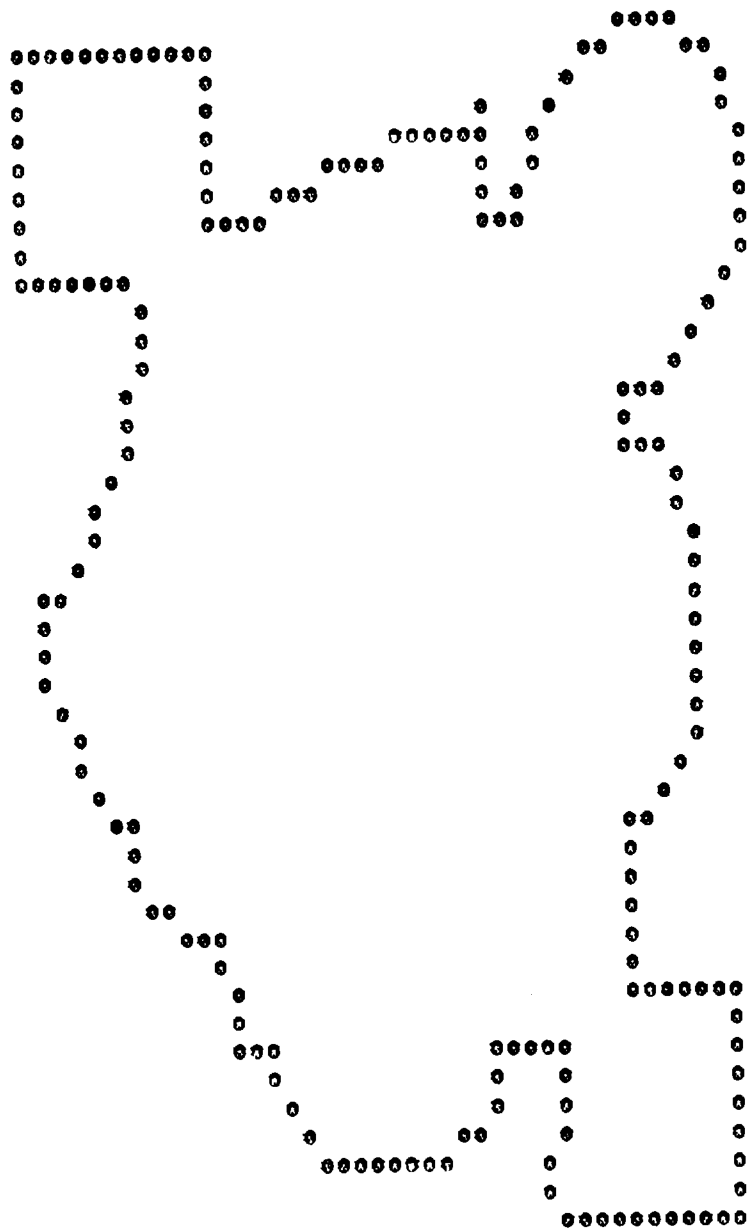
CORE REQUIREMENTS FOR VAR10
 COMMON       0  INSKEL COMMON      0
  VARIABLES  12326  PROGRAM     236



END OF COMPILATION
```

VARGUS 10A PATTERN NUMBER 1 1 6 71

L (1, 1)	H (1, 2)	L (1, 3)	H (2, 3)	L (3, 3)	H (3, 2)	L (3, 1)	H (2, 1)
26	22	27	11	4	11	10	9



I. Identification

1. Subroutine Name: JØIN
2. Category: Pattern Generation
3. Purpose: Create pattern matrices by randomly selecting four corner submatrices and four side submatrices. These eight submatrices are joined together into a closed figure by performing the appropriate rotation and positioning and storing into the pattern matrix.
4. Date: August, 1968
5. Programmer: Chip Bruce

II. Use Information

1. Language: 1800 Basic FORTRAN IV.
2. Machine: IBM 1800, 32K, 16-bit words.
3. Limitations: See VARGUS 10A documentation.
4. Usage: CALL JØIN (MATS, MATH, MATL, NH, NL).
5. Subroutine Parameters:

MATS: The 48 x 48 output matrix.

MATH: The matrix each row of which is a string of subscript pairs for side submatrices.

MATL: The matrix each row of which is a string of subscript pairs for corner submatrices.

NH: The number of side submatrices.

NL: The number of corner submatrices.

6. Output: HØRL: A vector the eight elements of which are numbers corresponding to the corner and side submatrices chosen to form a particular pattern. The elements are in the order beginning at the upper left of the pattern and moving clockwise around the figure.

7. Subroutine Required:

   RANDY: A pseudo-random number generator.

   RØTAT: The subroutine used to rotate the side and corner submatrices so that they form a continuous closed figure.

III. Mathematical Methods and References

Not Applicable.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
ROTAT
DMP FUNCTION COMPLETED
// FOR    30 JUN 71 13.722 HRS
*LIST ALL
*ONE WORD INTEGERS
*NONPROCESS PROGRAM
      SUBROUTINE JOIN (MATS, MATH, MATL, NH, NL,HORL)
      INTEGER SUBMX (16, 16), CHANI(8), CHANJ (8), HORL (8)
      DIMENSION MATS (48, 48), MATH (50, 100), MATL (50, 100)
      DATA CHANI / 0, 0, 0, 16, 32, 32, 32, 16 /
      DATA CHANJ / 0, 16, 32, 32, 32, 16, 0, 0 /
C
C     CLEAR OUTPUT MATRIX MATS
      DO 40 I = 1, 48
      DO 40 J = 1, 48
   40 MATS (I, J) = 0
C
      DO 110 IBLOC = 1, 8
C
C     CLEAR SUBMATRIX SUBMX
      DO 50 I = 1, 16
      DO 50 J = 1, 16
   50 SUBMX (I, J) = 0
C
      NTURN = (IBLOC - 1) / 2
      CALL RANDY(R)
C
      IF (IBLOC - 2 * (IBLOC / 2)) 60, 60, 80
C
   60 I = R * NH + 1
      DO 70 J=1,99,2
      K = MATH (I, J)
      L = MATH (I, J + 1)
      IF(K) 70,100,70
   70 SUBMX (K, L) = 1
      GO TO 100
C
   80 I = R * NL + 1
      DO 90 J=1,99,2
      K = MATL (I,J)
      L = MATL (I, J + 1)
      IF(K) 90,100,90
   90 SUBMX (K, L) = 1
  100 CALL ROTAT (SUBMX, 16, 16, NTURN)
      HORL (IBLOC) = I
C
      DO 110 I = 1, 16
      DO 110 J = 1, 16
      II = I + CHANI (IBLOC)
      JJ = J + CHANJ (IBLOC)
  110 MATS (II, JJ) = SUBMX (I, J)
      RETURN
      END
```

```
VARIABLE ALLOCATIONS
     R(R )=0000        SUBMX(I )=0103-0004 CHANI(I )=010B-0104 CHANJ(I )=0113-
 IBLOC(I )=0116        NTURM(I )=0117            K(I )=0118            L(I )=0119

STATEMENT ALLOCATIONS
 40    =0141  50    =016A  60    =01A1  70    =01CE  80    =01E5  90    =0212  10(

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS

CALLED SUBPROGRAMS
 RANDY    ROTAT    FADD     FMPY     FSTO     IFIX     FLOAT    ISTOX    STFAC    SBF

INTEGER CONSTANTS
     1=0120      48=0121       0=0122       8=0123       16=0124       2=0125

CORE REQUIREMENTS FOR JOIN
 COMMON        0  INSKEL COMMON       0
  VARIABLES     288  PROGRAM     354


END OF COMPILATION
```

I. Identification

1. Subroutine Name: RØTAT
2. Category: Pattern Modifier
3. Purpose: Accepts a matrix and rotates it by multiples of 90 degrees.
4. Date: July, 1968
5. Programmer: Chip Bruce

II. Use Information

1. Language: 1800 Basic FORTRAN IV.
2. Machine: IBM 1800, 32K, 16-bit words.
3. Limitation: Input matrix must be dimensioned to 16 x 16 in calling routine.
4. Subroutine Usage: CALL RØTAT (MX, NI, NJ, NTURN).
5. Subroutine Parameters:

   MX: The matrix to be rotated.

   NI: The number of rows.

   NJ: The number of columns.

   NTURN: The number of 90-degree rotations.
6. Subroutines Required:

   MØDUL: performs modular arithmetic.

III. Mathematical Method and References

Not Applicable.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
MODUL
DMP FUNCTION COMPLETED
// FOR ROTAT   30 JUN 71 13.713 HRS
*ONE WORD INTEGERS
*NONPROCESS PROGRAM
*LIST ALL
      SUBROUTINE ROTAT (MX, NI, NJ, NTURN)
C     ACCEPTS MATRIX MX (NI ROWS, NJ COLUMNS)
C     AND ROTATES IT BY NTURN TIMES NINETY DEGREES
      DIMENSION MX (16, 16), LX (16, 16)
C
      CALL MODUL (4, NTURN, NTURN)
      NTURN = NTURN + 1
      GO TO (120, 40, 60, 80), NTURN
C
C     90 DEGREE ROTATION
   40 DO 50 I = 1, NJ
      DO 50 J = 1, NI
      K = NI - J + 1
   50 LX (I, J) = MX (K, I)
      GO TO 100
C
C     180 DEGREE ROTATION
   60 DO 70 I = 1, NI
      DO 70 J = 1, NJ
      K = NI - I + 1
      L = NJ - J + 1
   70 LX (I, J) = MX (K, L)
      M = NI
      NI = NJ
      NJ = M
      GO TO 100
C
C     270 DEGREE ROTATION
   80 DO 90 I = 1, NJ
      DO 90 J = 1, NI
      K = NJ - I + 1
   90 LX (I, J) = MX (J, K)
C
C     LOAD ROTATED MATRIX
  100 DO 110 I = 1, NJ
      DO 110 J = 1, NI
  110 MX (I, J) = LX (I, J)
C
  120 RETURN
      END

VARIABLE ALLOCATIONS
     LX(I )=00FF-0000     I(I )=0100          J(I )=0101          K(I )=0102

STATEMENT ALLOCATIONS
 40   =013D  50   =014D  60   =0175  70   =018D  80   =01C1  90   =01D1  10(

FEATURES SUPPORTED
```

```
 NONPROCESS
 ONE WORD INTEGERS

CALLED SUBPROGRAMS
 MODUL    COMGO    ISTOX    SUBSC    SUBIN

INTEGER CONSTANTS
     4=0108        1=0109

CORE REQUIREMENTS FOR ROTAT
 COMMON        0  INSKEL COMMON       0
  VARIABLES     264  PROGRAM     278


END OF COMPILATION
```

I. Identification

1. Subroutine Name: MØDUL

2. Category: Computational

3. Purpose: Perform modular arithmetic

4. Date: August, 1968

5. Programmer: Bob Breckenridge

II. Use Information

1. Language: 1800 Basic FORTRAN IV.

2. Machine: IBM 1800, 32K, 16-bit words.

3. Limitations: Operates on one number per call.

4. Subroutine Usage: CALL MØDUL (MØDØP, IX, MØDX).

5. Subroutine Parameters:

MØDØP: The modulus.

IX: The input value.

MODX: The output value.

6. Subroutines Required: None.

III. Mathematical Method and References

None.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
VAR10
DMP FUNCTION COMPLETED
// FOR    30 JUN 71 13.707 HRS
*ONE WORD INTEGERS
*LIST ALL
*NONPROCESS PROGRAM
      SUBROUTINE MODUL (MODOP,IX,MODX)
C   SUBROUTINE FOR DOING MODULAR ARITHMETIC
C   MODOP IS THE MODULAR OPERATOR
C   IX IS THE INPUT VALUE
C   MODX IS THE OUTPUT MOD VALUE
C
      MODX=IX
      GO TO 20
   10 MODX=MODX-MODOP
   20 IF (MODX-MODOP)30,10,10
   30 CONTINUE
      RETURN
      END

STATEMENT ALLOCATIONS
 10    =0013  20    =0019  30    =001F

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS

CALLED SUBPROGRAMS
 SUBIN

CORE REQUIREMENTS FOR MODUL
 COMMON         0  INSKEL COMMON       0
  VARIABLES        0  PROGRAM       34



END OF COMPILATION
```

I. Identification

1. Subroutine Name: CØNG

2. Category: Comparison of Patterns

3. Purpose: Computes an estimate of the similarity of two VARGUS 10 patterns.

4. Date: August, 1969

5. Programmer: Earl M. Greer

II. Use Information

1. Language: 1800 Basic FØRTRAN IV.

2. Machine: IBM 1800, 32K, 16-bit words.

3. Limitations: Matrices dimensioned to 48 x 48.

4. Subroutine Usage:

   CALL CØNG (MX, NI, NJ, LX, MI, MJ, IBLUR, CØNGR).

5. Subroutine Parameters:

   MX: Pattern matrix.

   NI: Number of rows.

   NJ: Number of columns.

   LX: Comparison matrix (typically the schema).

   MI: Number of rows in comparison matrix.

   MJ: Number of columns in comparison matrix.

   IBLUR: If IBLUR = 1, LX is blurred as well as MX.

   CØNGR: Returns the similarity measure.

6. Subroutines Required:

   BLUR: Blurs the input matrix using a 7 x 7 element random walk matrix.

III. Mathematical Method and References

SUM contains a measure of the degree of overlap of the two patterns. SUMZ contains a measure of the maximum possible overlap; i.e., a comparison of LX with itself. CØNGR is thus the percentage of maximum possible overlap of MX with LX.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
PATOT
DMP FUNCTION COMPLETED
// FOR    01 JUL 71 23.606 HRS
*LIST ALL
*ONE WORD INTEGERS
*NONPROCESS PROGRAM
      SUBROUTINE CONG (MX, NI, NJ, LX, MI, MJ, IBLUR,CONGR)
C  SUBROUTINE CONG               EARL M. GREER                     AUGUST 1, 196
C     IBM 1800
C  ACCEPTS TWO MATRICES FROM CALLING STATEMENT,
C   BLURS THE FIRST, MULTIPLIES THE TWO MATRICES,
C   AND SUMS THE RESULTING MATRIX.
C
C  IF IBLUR = 1 THE SECOND MATRIX IS ALSO BLURRED ALONG WITH THE FIRST.
C   THIS SECOND MATRIX IS SQUARED TO PROVIDE A STANDARD,  THE MAXIMUM
C   POSSIBLE CONGRUENCE.
C
C  THE DIFFERENCE BETWEEN THE STANDARD AND ACTUAL CONGRUENCE IS THE
C   DEVIATION.  THE ACTUAL CONGRUENCE IS DIVIDED BY THE STANDARD AND
C   MULTIPLIED BY 100 TO FIND THE PERCENT CONGRUENCE.
C
      DIMENSION MX(48,48), LX(48,48)
      COMMON FX(54,54)
      IF (IBLUR - 1) 60,50,60                                          CON
   50 CALL BLUR(LX, MI, MJ)                                             CON
   60 CALL BLUR(MX, NI, NJ)                                             CON
      SUM = 0.0                                                         CON
      SUM2 = 0.0                                                        CON
      DO 70 I = 1,NI                                                    CON
      DO 70 J = 1,NJ                                                    CON
      FX(I,J) = MX(I,J) * LX(I,J)                                       CON
   70 SUM = SUM + FX(I,J)                                               CON
      DO 90 I = 1,MI                                                    CON
      DO 90 J = 1,MJ                                                    CON
      FX(I,J) = LX(I,J) * LX(I,J)                                       CON
   90 SUM2 = SUM2 + FX(I,J)                                             CON
      DIFF = SUM2 - SUM                                                 CON
      CONGR = (SUM / SUM2) * 100.0                                      CON
      RETURN                                                            CON
      END                                                               CON

VARIABLE ALLOCATIONS
   FX(RC)=FFFE-E938    SUM(R )=0000        SUM2(R )=0002        DIFF(R )=0004

STATEMENT ALLOCATIONS
 50    =0030  60    =0035  70    =0062  90    =009C

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS

CALLED SUBPROGRAMS
 BLUR     FADDX    FSUB     FMPY     FDIV     FLD      FSTO     FSTOX    FLOAT    SU
```

```
REAL CONSTANTS
  .000000E 00=000A      .100000E 03=000C

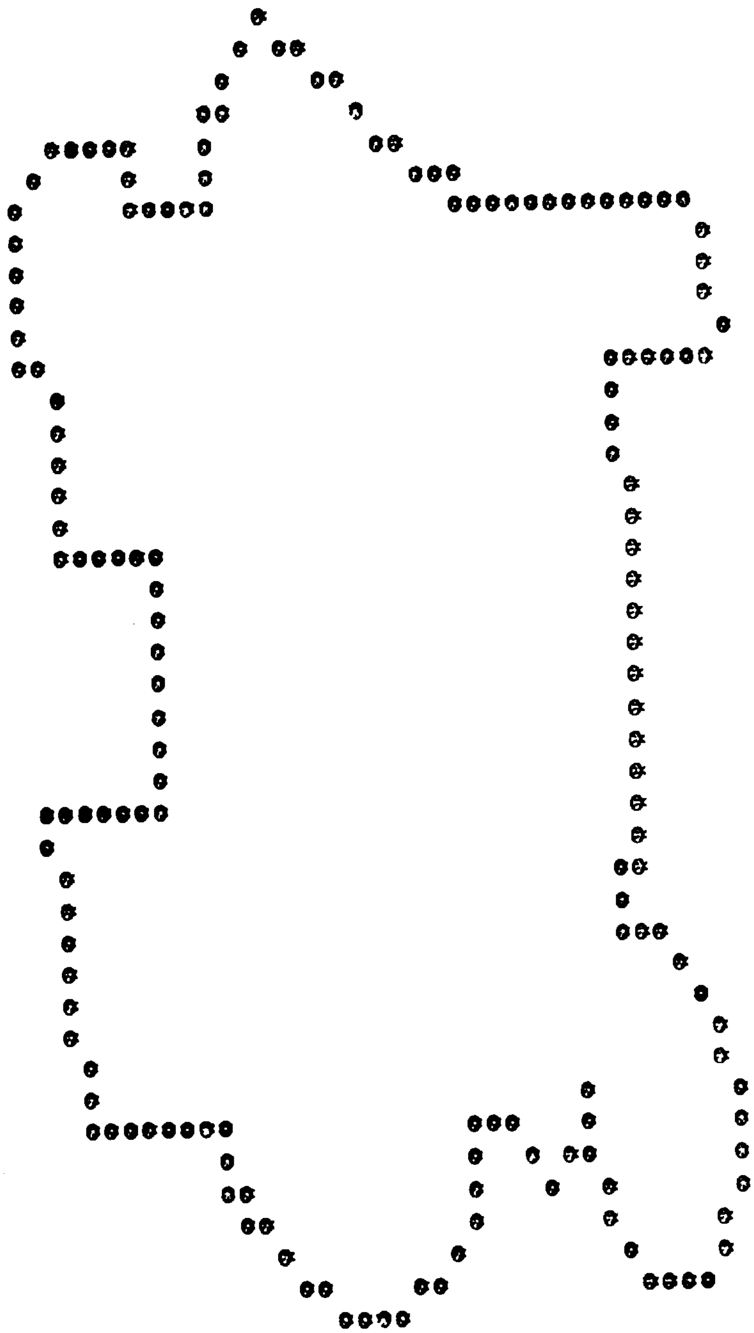
INTEGER CONSTANTS
     1=000E

CORE REQUIREMENTS FOR CONG
 COMMON    5832  INSKEL COMMON       0
  VARIABLES      10   PROGRAM     188

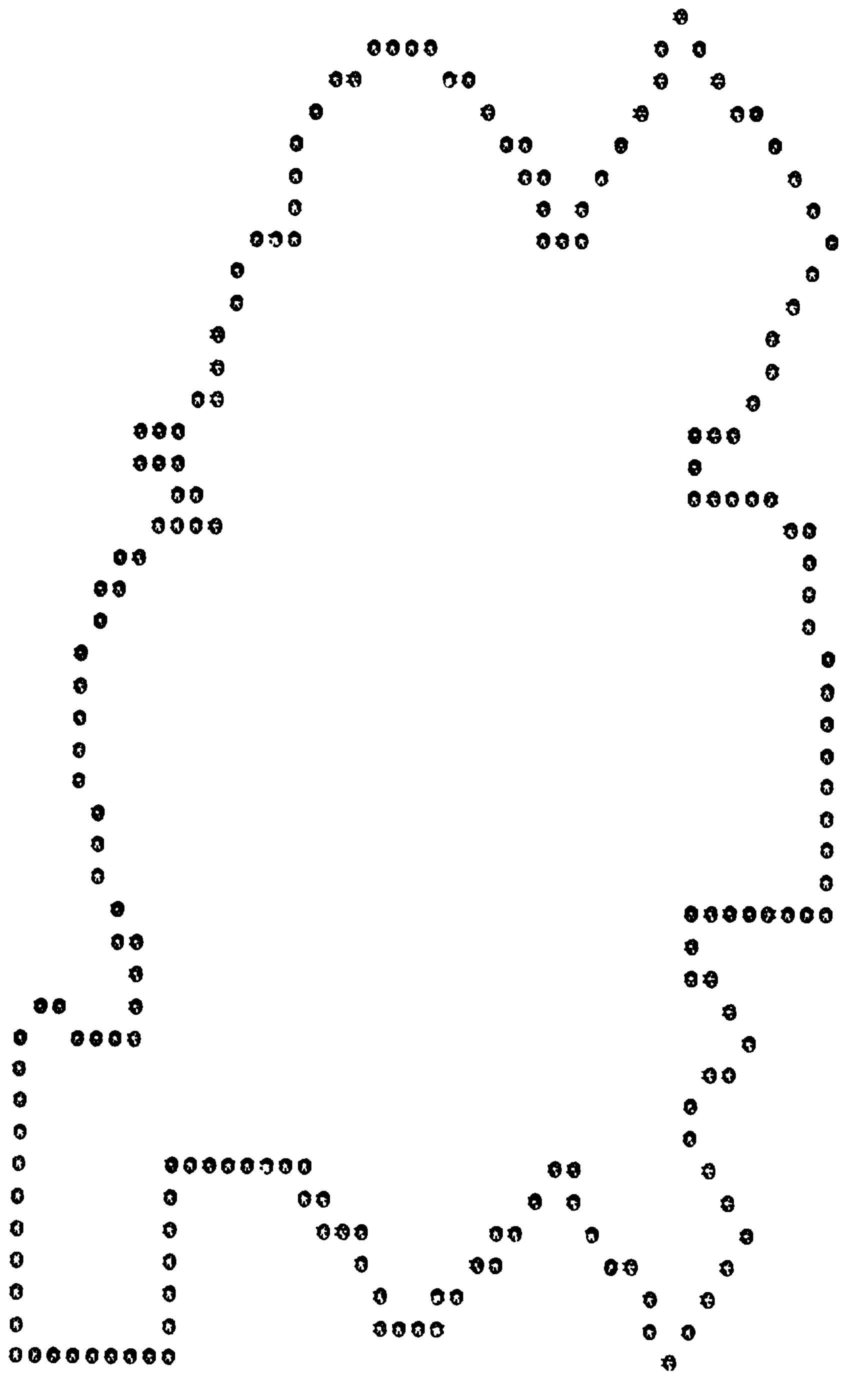


END OF COMPILATION
```

VARGUS 10A PATTERN 2



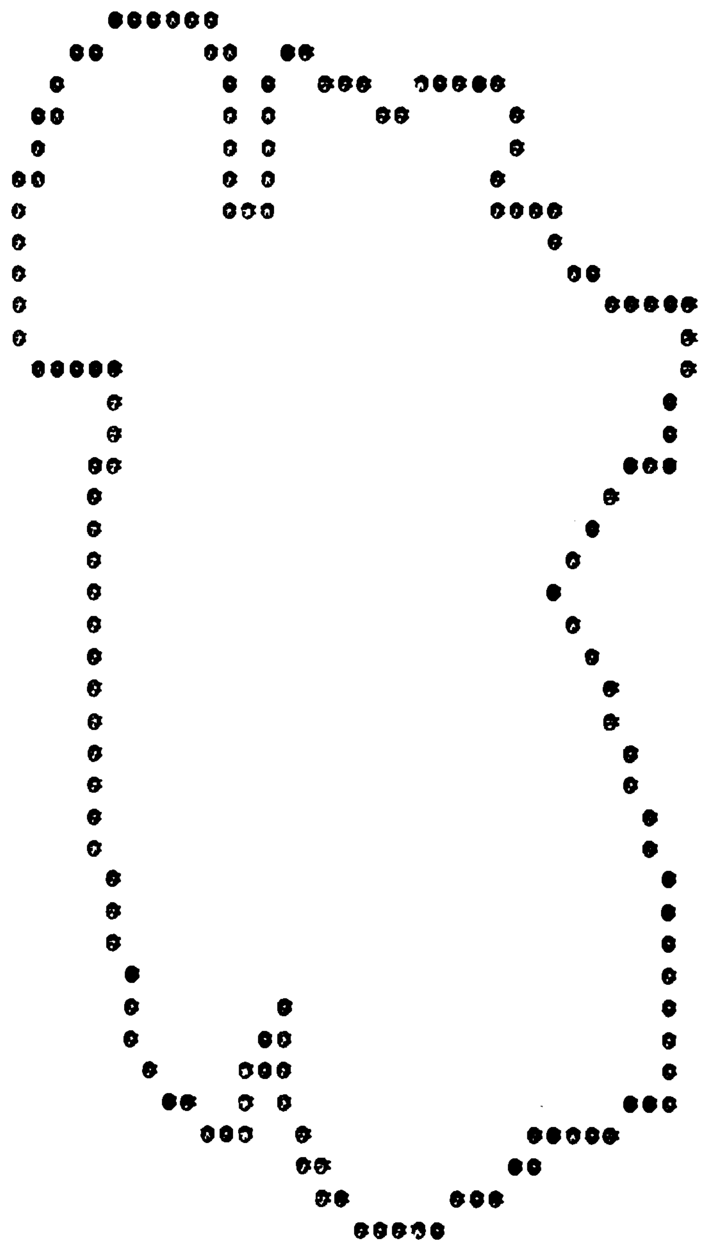
VARGUS 10A PATTERN 3



RESULT OF CONG ON VARGUS 10-A PATTERN 2 AND PATTERN 3 WITH IBLUR = 0
CONG RETURNS 322.63

RESULT OF CONG AS ABOVE WITH IBLUR = 1
CONG RETURNS 77.34

VARGUS 10A PATTERN 4



```
RESULT OF CONG ON VARGUS 10-A PATTERN 2 AND PATTERN 4 WITH IBLUR = 0
CONG RETURNS    353.69


RESULT OF CONG AS ABOVE WITH IBLUR = 1
CONG RETURNS    77.62
```

I. Identification

1. Subroutine Name: BLUR

2. Category: Pattern Manipulation

3. Purpose: To accept a binary matrix and simulate all possible 3-step random walks for every "black" cell. Thus a weight or loading is built up on a scale from 0 to 9 representing the probability that a given cell might be black.

4. Date: August, 1968

5. Programmer: Bob Breckenridge

II. Use Information

1. Language: 1800 Basic FORTRAN IV.

2. Machine: IBM 1800, 32K, 16-bit words.

3. Limitations: Pattern matrix is a 48 x 48 fixed point matrix.

4. Subroutine Usage: CALL BLUR (MX, NI, NJ).

5. Subroutine Parameters:

   MX: pattern matrix.

   NI: number of rows.

   NJ: number of columns.

6. Subroutines Required:

   RSCAL: Rescales a matrix such that values are whole numbers from 0 to 9.

III. Mathematical Methods and References

None.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
RSCAL
DMP FUNCTION COMPLETED
// FOR    01 JUL 71 23.580 HRS
*LIST ALL
*ONE WORD INTEGERS
*NONPROCESS PROGRAM
      SUBROUTINE BLUR(MX,NI, NJ)
C
      REAL IMX (54, 54)
      DIMENSION MX (48, 48), IWALK (49)
      COMMON IMX
      DATA IWALK/1,3,6,7,6,3,1,3,6,10,10,10,6,3,6,10,25,27,25,10,6,7,10,
     127,30,27,10,7,6,10,25,27,25,10,6,3,6,10,10,10,6,3,1,3,6,7,6,3,1/
C
      NJJ=NJ+3
      NII=NI+3
      IN=NI+6
      JN=NJ+6
C
C     SET WORK MATRIX TO ZERO
      DO 20 I=1,IN
      DO 20 J=1,JN
   20 IMX(I,J)=0
C
C     CHECK INPUT MATRIX FOR SIGNAL
      DO 50 I=1,NI
      DO 50 J=1,NJ
      IF (MX(I,J))50,50,30
   30 IOVER=I+6
      JDOWN=J+6
      KOUNT=1
      DO 40 II=I,IOVER
      DO 40 JJ=J,JDOWN
      IMX(II,JJ)=IMX(II,JJ)+IWALK(KOUNT)
   40 KOUNT=KOUNT+1
   50 CONTINUE
C
C
C     SET BORDER AROUND MATRIX TO ZERO
      DO 100 K=4,NJJ
      IMX(4,K)=0
  100 IMX(NII,K)=0
      DO 105 K=4,NII
      IMX(K,4)=0
  105 IMX(K,NJJ)=0
      DO 110 K=4,NII
      DO 110 J=4,NJJ
  110 MX(K-3,J-3)=IMX(K,J)
      CALL RSCAL (1, IMX, MX, NI, NJ)
      RETURN
      END

VARIABLE ALLOCATIONS
   IMX(RC)=FFFE-E938 IWALK(I )=0032-0002   NJJ(I )=0033        NII(I )=0034
```

```
    I(I )=0037            J(I )=0038        IOVER(I )=0039        JDOWN(I )=003A
   JJ(I )=003D            K(I )=003E

STATEMENT ALLOCATIONS
 20    =0078  30    =00A9  40    =00DE  50    =00F6  100   =0116  105   =0139  11

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS

CALLED SUBPROGRAMS
 RSCAL   FADD    FLDX    FSTO    FSTOX   IFIX    FLOAT   ISTOX   SUBSC   SU

INTEGER CONSTANTS
    3=0042       6=0043       1=0044       0=0045       4=0046

CORE REQUIREMENTS FOR BLUR
 COMMON   5832  INSKEL COMMON      0
  VARIABLES      66  PROGRAM     324


END OF COMPILATION
```

I. Identification

1. Subroutine Name: RSCAL

2. Category: Computational

3. Purpose: To rescale a matrix such that each cell contains a whole number in the interval 0 to 9.

4. Date: August, 1968

5. Programmer: Bob Breckenridge

II. Use Information

1. Language: 1800 Basic FORTRAN IV.

2. Machine: IBM 1800, 32K, 16-bit words.

3. Limitations: Matrix dimensions up to 48 x 48. Input matrix is either fixed or floating point. Output matrix is always fixed point.

4. Subroutine Usage: CALL RSCAL (MODE, FMX, MX, NI, NJ).

5. Subroutine Parameters:

MODE: Indicates whether data matrix is fixed point (MODE = 1), or floating point (MODE = 2).

FMX: Floating-point input matrix.

MX: Fixed-point input matrix. Returns rescaled matrix.

NI: Number of rows.

NJ: Number of columns.

6. Subroutines Required:

MIMAX: Find the maximum and minimum values in a matrix.

III. Mathematical Method and References

Simple scaling procedure.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
CON
DMP FUNCTION COMPLETED
// FOR    01 JUL 71 23.573 HRS
*LIST ALL
*ONE WORD INTEGERS
*NONPROCESS PROGRAM
      SUBROUTINE RSCAL(MODE,FMX,MX,NI,NJ)
      DIMENSION FMX(54,54),MX(48,48)
      CALL MIMAX(MODE,FMX,MX,NI,NJ,BIG,SMALL)
      DIVID=(BIG-SMALL)/9.9
      DO 5 I=1,NI
      DO 5 J=1,NJ
      TEMP=(FMX(I,J)-SMALL)/DIVID
    5 MX(I,J)=TEMP
      RETURN
      END

VARIABLE ALLOCATIONS
   BIG(R )=0000       SMALL(R )=0002       DIVID(R )=0004       TEMP(R )=0006

STATEMENT ALLOCATIONS
 5     =0048

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS

CALLED SUBPROGRAMS
 MIMAX    FSUB    FDIV    FLD    FLDX    FSTO    IFIX    ISTOX    SUBSC    SU

REAL CONSTANTS
  .990000E 01=000C

INTEGER CONSTANTS
     1=000E

CORE REQUIREMENTS FOR RSCAL
 COMMON        0  INSKEL COMMON      0
  VARIABLES      12   PROGRAM      92



END OF COMPILATION
```

I. Identification

1. Subroutine Name: MIMAX

2. Category: Computational

3. Purpose: Find the maximum and minimum values in a matrix.

4. Date: August, 1968

5. Programmer: Bob Breckenridge

II. Use Information

1. Language: 1800 Basic FORTRAN IV.

2. Machine: IBM 1800, 32K, 16-bit words.

3. Limitations: Matrix dimensions up to 48 x 48.

4. Subroutine Usage: CALL MIMAX (MODE, FMX, MX, NI, NJ, BIG, SMALL).

5. Subroutine Parameters:

MODE: Indicates whether data matrix is fixed point (MODE = 1), or floating point (MODE = 2).

FMX: Floating-point input matrix.

MX: Fixed-point input matrix.

NI: Number of rows.

NJ: Number of columns.

BIG: Return largest value in matrix to calling program.

SMALL: Returns smallest value in matrix to calling program.

6. Subroutines Required: None.

III. Mathematical Methods and References

None.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
BLUR
DMP FUNCTION COMPLETED
// FOR    01 JUL 71 23.590 HRS
*LIST ALL
*ONE WORD INTEGERS
*NONPROCESS PROGRAM
      SUBROUTINE MIMAX(MODE,FMX,MX,NI,NJ,BIG,SMALL)
      DIMENSION FMX(54,54),MX(48,48)
      GO TO (5,10),MODE
    5 DO 7 I=1,NI
      DO 7 J=1,NJ
    7 FMX(I,J)=MX(I,J)
   10 BIG=FMX(1,1)
      SMALL=BIG
      DO 15 I=1,NI
      DO 15 J=1,NJ
      IF(BIG-FMX(I,J)) 11,15,13
   11 BIG=FMX(I,J)
      GO TO 15
   13 IF(SMALL-FMX(I,J)) 15,15,14
   14 SMALL=FMX(I,J)
   15 CONTINUE
      RETURN
      END

VARIABLE ALLOCATIONS
     I(I )=0000          J(I )=0001

STATEMENT ALLOCATIONS
 5     =0028  7     =0030  10    =0057  11    =0079  13    =0086  14    =0094  15

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS

CALLED SUBPROGRAMS
 FSUBX    FLD      FLDX     FSTO     FSTOX    FLOAT    COMGO    LDFAC    SUBSC    SU

INTEGER CONSTANTS
     1=0004

CORE REQUIREMENTS FOR MIMAX
 COMMON       0  INSKEL COMMON       0
  VARIABLES       4  PROGRAM     176



END OF COMPILATION
```

I. Identification

1. Subroutine Name: SØLID
2. Category: Pattern Manipulation
3. Purpose: Accepts a closed figure represented in matrix form and fills in the interior.
4. Date: July, 1969
5. Programmer: David R. Harris

II. Use Information

1. Language: 1800 Basic FORTRAN IV.
2. Machine: IBM 1800, 32K, 16-bit words.
3. Limitations: The program is designed to accept a 48 x 48 matrix. The size of IARY and JARY may be reduced to save space but at a cost in running time.
4. Subroutine Usage: CALL SØLID (INARY).
5. Subroutine Parameters:

   INARY: a 48 x 48 input matrix containing the pattern. This same matrix returns the solid figure so that the original pattern is destroyed.
6. Subroutines Required: None.

III. Mathematical Methods and References

Not Applicable.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
WIDER
DMP FUNCTION COMPLETED
// FOR SOLID    30 JUN 71 13.893 HRS
*ONE WORD INTEGERS
*LIST ALL
*NON PROCESS PROGRAM
      SUBROUTINE SOLID(INARY)
      DIMENSION INARY(48,48),    ARY(54,54), IARY(54), JARY(54)
      COMMON ARY
C
      DO 10 I=1,48
      DO 10 J=1,48
   10 ARY(I+2,J+2)= INARY(I,J)
C     THIS PUTS THE ORIGINAL ARRAY IN THE WORKING ARRAY
      M1=52
      M2=51
      M3=50
C
      DO 11  I=1,M1
      ARY(1,I)=-1
      ARY(M1,I)=-1
      ARY(I,1)=-1
   11 ARY(I,M1)=-1
C     THIS PUTS -1 AROUND THE BORDER
      DO 15  I=2,M2
      ARY(2,I)=0
      ARY(M2,I)=0
      ARY(I,2)=0
   15 ARY(I,M2)=0
C
      IP1=1
      IP2=2
      IARY(1)=2
      JARY(1)=2
      ARY(2,2)= -1.
C     THIS SECTION FILLS IN -1 AROUND THE FIGURE
   35 K1=IARY(IP1)
      K2 = JARY(IP1)
C
      IF  (ARY(K1+1,K2   )) 50,45,50
   45 ARY(K1+1,K2   )=-1.
      IARY(IP2)=K1+1
      JARY(IP2)=K2
      IP2=IP2+1
   50 IF(ARY(K1   ,K2-1)) 60,55,60
   55 ARY(K1   ,K2-1)=-1.
      IARY(IP2)=K1
      JARY(IP2)=K2-1
      IP2=IP2+1
   60 IF  (ARY(K1   ,K2+1)) 70,65,70
   65 ARY(K1   ,K2+1)=-1.
      IARY(IP2)=K1
      JARY(IP2)=K2+1
      IP2=IP2+1
```

```
   70 IF (ARY(K1-1,K2  )) 80,75,80
   75 ARY(K1-1,K2  )=-1.
      IARY(IP2)=K1-1
      JARY(IP2)=K2
      IP2=IP2+1
   80 IP1=IP1+1
      IF (IP1-IP2) 85,110,85
   85 IF (IP2+4-54) 95,90,90
   90 IARY(IP2)=-1
      IP2=1
   95 IF (IARY(IP1)) 100,100,35
  100 IP1=1
      GO TO 35
  110 DO 200  I=3,M3
      DO 200  J=3,M3
      IF (ARY(I,J)) 200,150,150
  150 INARY(I-2,J-2)=1
  200 CONTINUE
      RETURN
      END

VARIABLE ALLOCATIONS
   ARY(RC)=FFFE-C938   IARY(I )=0035-0000   JARY(I )=0068-0036      I(I )=006C
    M2(I )=006F           M3(I )=0070          IP1(I )=0071          IP2(I )=0072

STATEMENT ALLOCATIONS
 10   =0094  11   =00EE  15   =0128  35   =0158  45   =0173  50   =0196  55
 75   =0200  80   =0223  85   =022F  90   =0237  95   =0245  100  =024E  11(

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS

CALLED SUBPROGRAMS
 FLD      FLDX     FSTOX    FLOAT    ISTOX    LDFAC    SUBSC    SNR      SUBIN

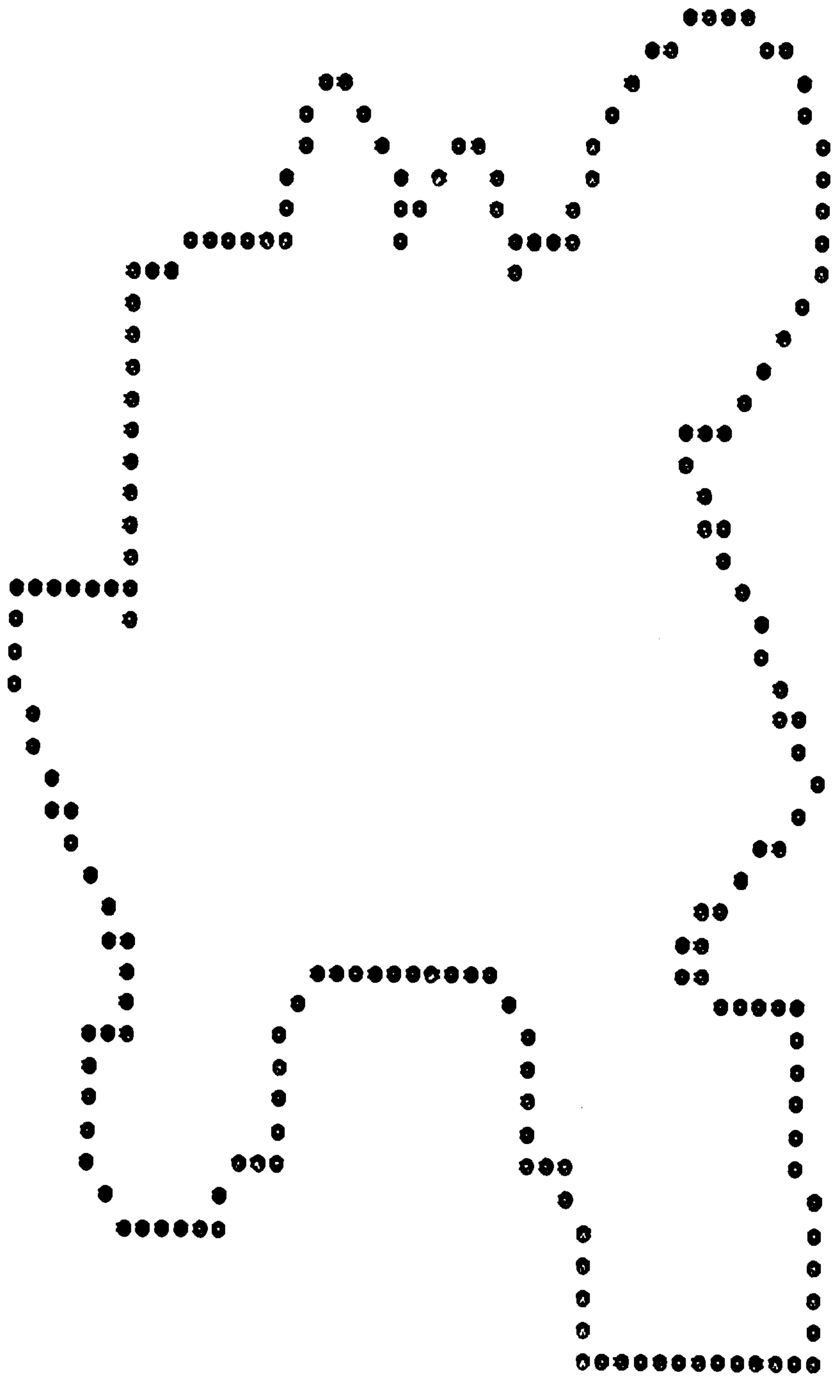
REAL CONSTANTS
  .100000E 01=007A

INTEGER CONSTANTS
     1=007C      48=007D      52=007E      51=007F      50=0080      2=0081

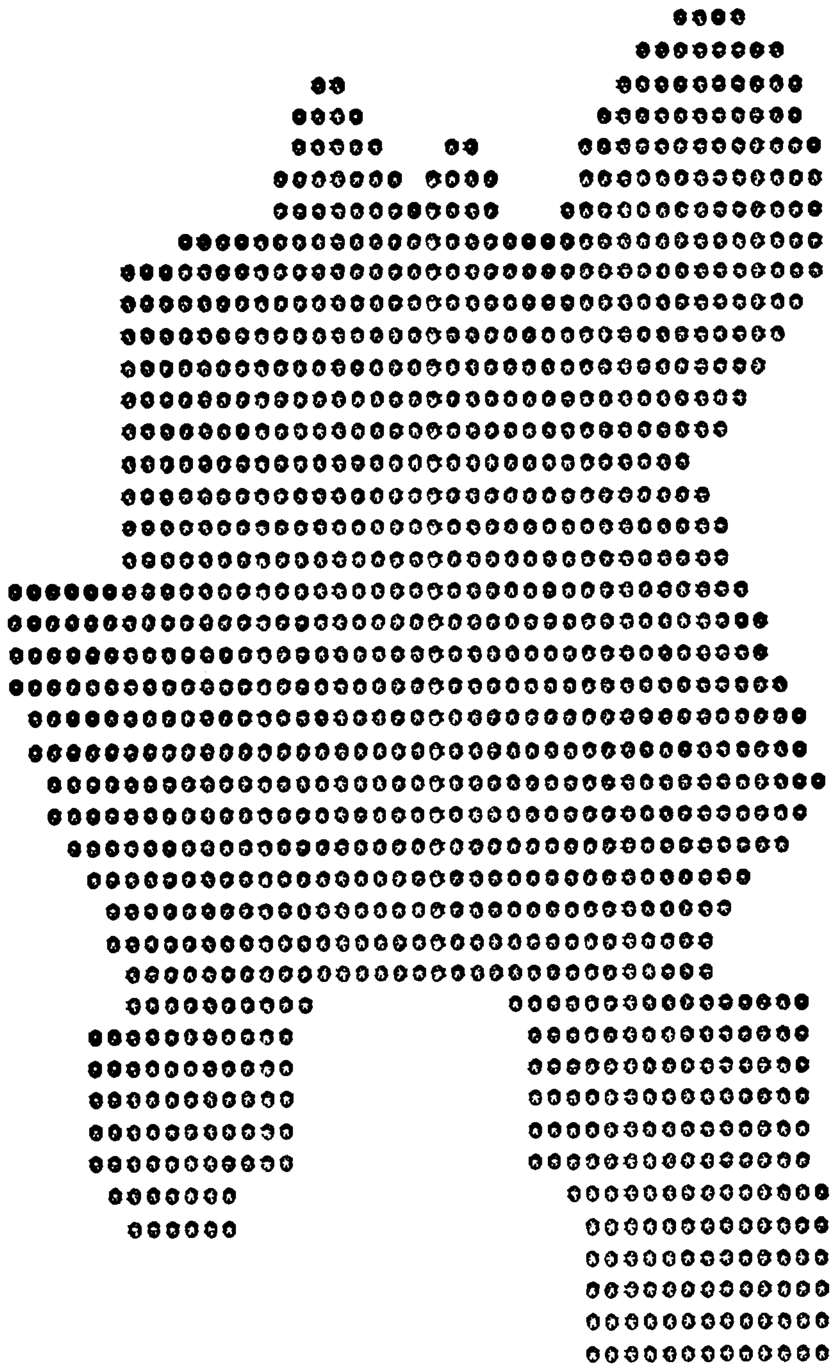
CORE REQUIREMENTS FOR SOLID
 COMMON   5832  INSKEL COMMON      0
  VARIABLES    122  PROGRAM    526


END OF COMPILATION
```

BASIC VARGUS 10A PATTERN



EFFECT OF SOLID ON PATTERN



I. Identification

1. Subroutine Name: WIDEN

2. Category: Pattern Manipulation

3. Purpose: To widen lines of a figure centered in a matrix.

4. Date: September, 1968

5. Programmer: Chip Bruce

II. Use Information

1. Language: 1800 Basic FORTRAN IV.

2. Machine: IBM 1800, 32K, 16-bit words.

3. Limitation: Widens line one cell thick to 3 cells thick. Multiple calls to the subroutine will result in still thicker lines. Matrix should be dimensioned to 48 x 48.

4. Subroutine Usage: CALL WIDEN (MX, NI, NJ).

5. Subroutine Parameters:

   MX: The matrix containing the pattern.

   NI: The number of rows.

   NJ: The number of columns.

6. Subroutines Required: None.

III. Mathematical Method and References

Each positive cell of the matrix is treated as the center of a 3 x 3 submatrix and its eight surrounding cells are set equal to 1.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
U
DMP FUNCTION COMPLETED
// FOR WIDEN    30 JUN 71 13.879 HRS
*LIST ALL
*NONPROCESS PROGRAM
*ONE WORD INTEGERS
      SUBROUTINE WIDEN (MX, NI, NJ)
C     ACCEPTS MATRIX MX (NI ROWS, NJ COLUMNS)
C     AND PLACES 1 S IN EVERY POSITION OF A 3 X 3 SUBMATRIX OF MX
C     WHICH IS CENTERED SUCCESSIVELY ON POSITIVE ENTRIES OF MX
      DIMENSION MX (48, 48), LX (48, 48)
      DO 5 I=1,NI
      DO 5 J=1,NJ
5     LX(I,J)=0
      DO 30 I = 1, NI
      DO 30 J = 1, NJ
      IF (MX (I, J)) 30, 30, 10
   10 DO 20 K = 1, 3
      DO 20 L = 1, 3
      M = I + K - 2
      N = J + L - 2
   20 LX (M, N) = 1
   30 CONTINUE
      DO 40 I = 1, NI
      DO 40 J = 1, NJ
      MX (I, J) = LX (I, J)
40    CONTINUE
      RETURN
      END

VARIABLE ALLOCATIONS
    LX(I )=08FF-0000      I(I )=0900          J(I )=0901          K(I )=0902
     N(I )=0905

STATEMENT ALLOCATIONS
 5     =0922  10     =0952  20     =096A  30     =0987  40     =09AC

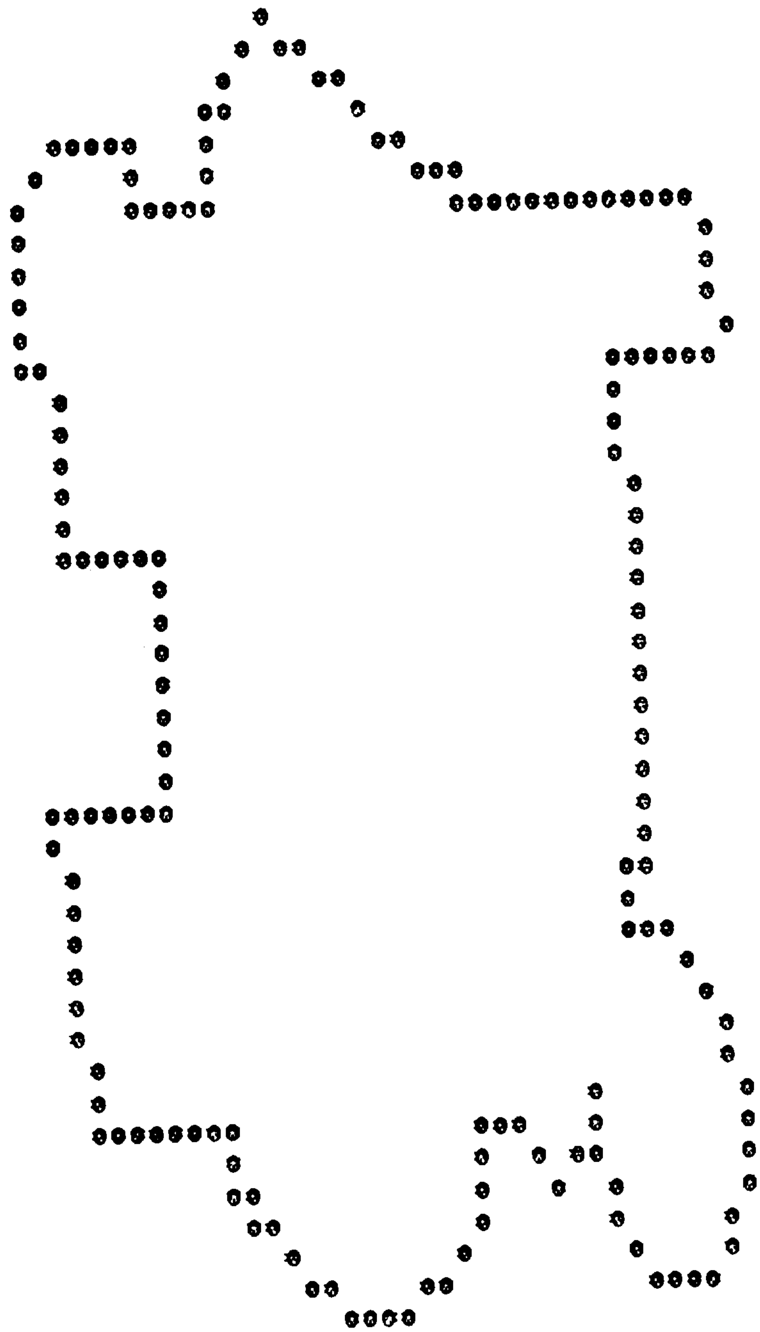
FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS

CALLED SUBPROGRAMS
 ISTOX    SUBSC    SUBIN

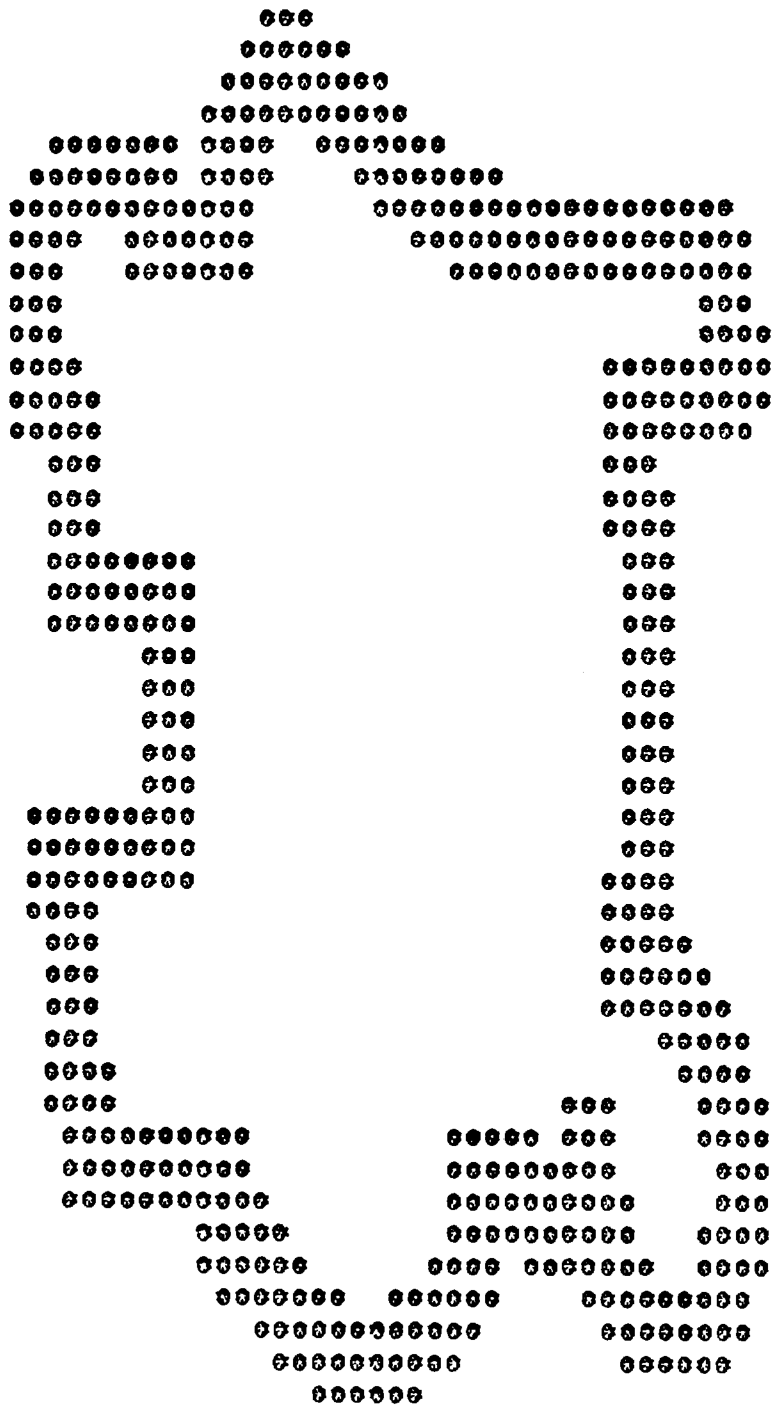
INTEGER CONSTANTS
     1=0908       0=0909       3=090A       2=090B

CORE REQUIREMENTS FOR WIDEN
 COMMON        0  INSKEL COMMON       0
  VARIABLES    2312  PROGRAM     184
```

BASIC VARGUS 10A PATTERN



EFFECT OF WIDEN ON PATTERN



I. Identification

1. Subroutine Name: WIDER

2. Category: Pattern Manipulation

3. Purpose: To widen lines of a closed figure inwardly and retain the original figure as the outer perimeter.

4. Date: September, 1968

5. Programmer: Bob Breckenridge

II. Use Information

1. Language: 1800 Basic FORTRAN IV.

2. Machine: IBM 1800, 32K, 16-bit words.

3. Limitations: Widens to 3 cells thickness. Matrix should be dimensioned to 48 x 48.

4. Subroutine Usage: CALL WIDER (MX, NI, NJ).

5. Subroutine Parameters:

   MX: pattern matrix.

   NI: number of rows.

   NJ: number of columns.

6. Subroutines Required:

   SØLID: Fills in closed figure.

   WIDEN: Thickens lines to width 3.

III. Mathematical Methods and References

None.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
WIDEN
DMP FUNCTION COMPLETED
// FOR WIDER    30 JUN 71 13.887 HRS
*NONPROCESS PROGRAM
*LIST ALL
*ONE WORD INTEGERS
      SUBROUTINE WIDER (MX,NI,NJ)
      DIMENSION MX(48,48),LX(48,48)
      DO 5 I=1,NI
      DO 5 J=1,NJ
    5 LX(I,J)=MX(I,J)
      CALL SOLID(LX)
      CALL WIDEN(MX,NI,NJ)
      CALL WIDEN(MX,NI,NJ)
      DO 6 I=1,NI
      DO 6 J=1,NJ
    6 MX(I,J)=MX(I,J)*LX(I,J)
      RETURN
      END

VARIABLE ALLOCATIONS
    LX(I )=08FF-0000     I(I )=0900           J(I )=0901

STATEMENT ALLOCATIONS
 5    =0920  6    =0952

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS

CALLED SUBPROGRAMS
 SOLID    WIDEN    ISTOX    SUBSC    SUBIN

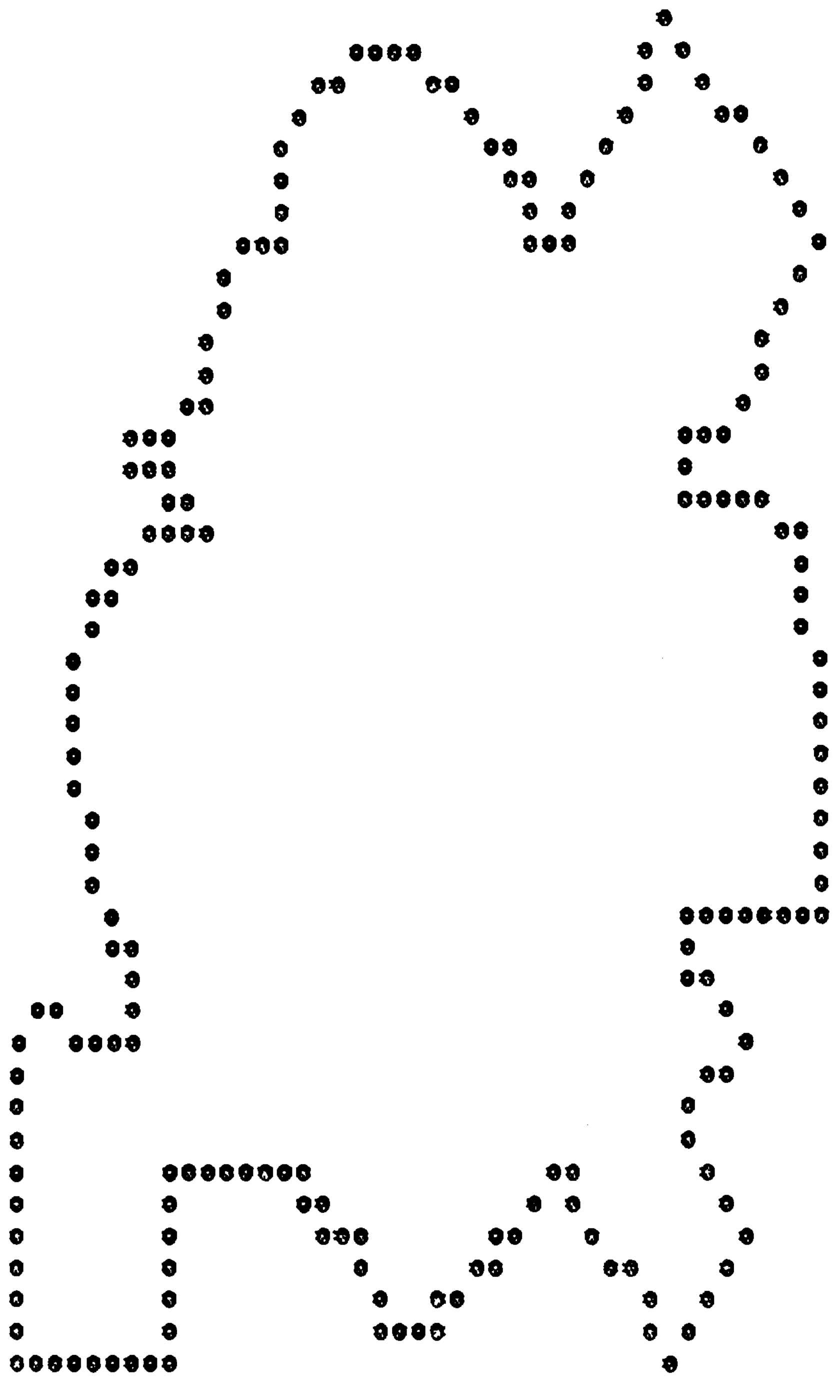
INTEGER CONSTANTS
     1=0904

CORE REQUIREMENTS FOR WIDER
 COMMON       0  INSKEL COMMON       0
  VARIABLES    2308   PROGRAM     112

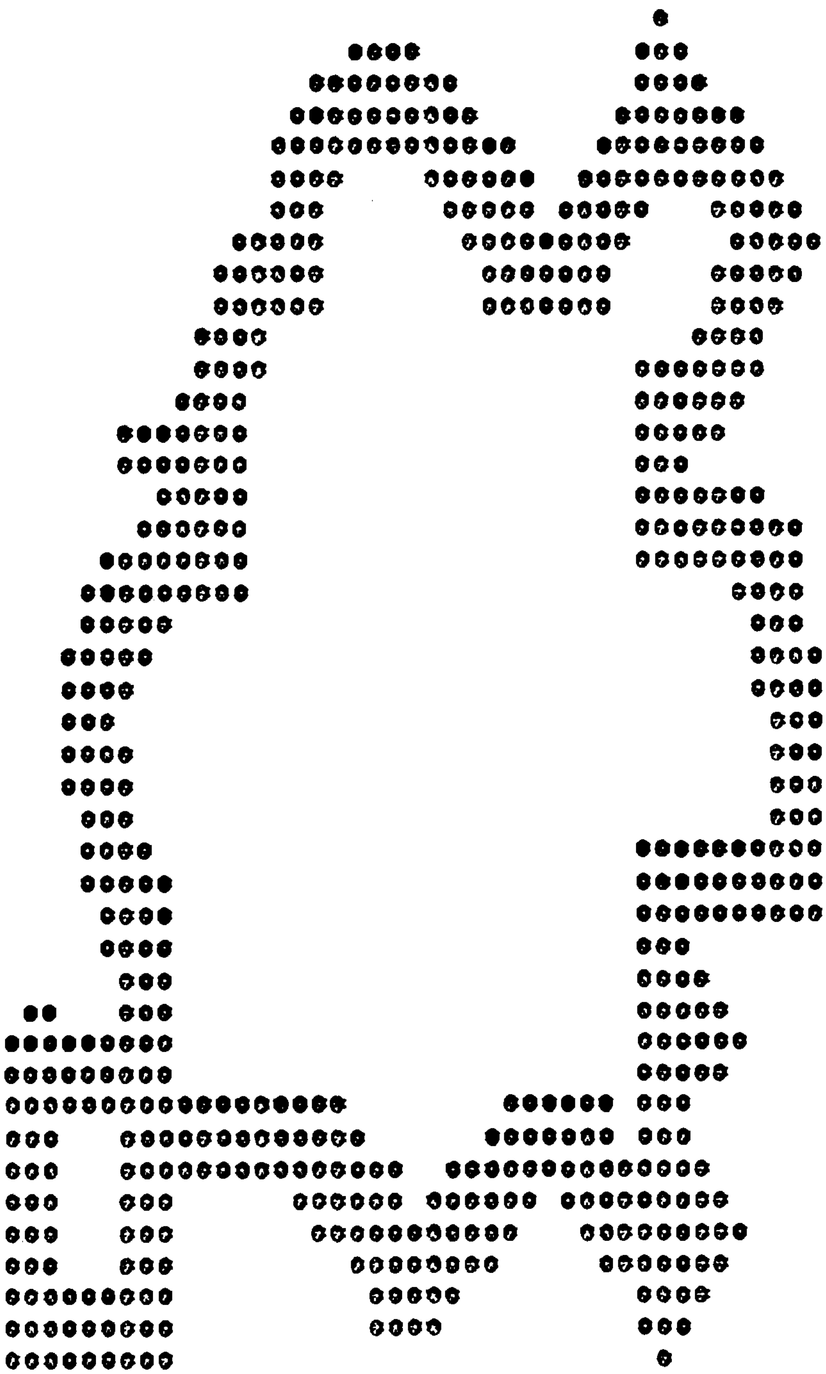


END OF COMPILATION
```

BASIC VARGUS 10A PATTERN



EFFECT OF WIDER ON PATTERN



I. Identification

1. Subroutine Name: RANDY
2. Category: Pseudo-random Number Generator
3. Purpose: Compute uniformly distributed random floating-point numbers between 0.0 and 1.0.
4. Date: March 25, 1968
5. Programmer: Bill Randol Brown
   Statistical tests in Remarks Section performed by Mike Abbamonte, April 20, 1971.

II. Use Information

1. Language: IBM Basic Fortran IV.
2. Machine: IBM 1800, 32K, 16-bit words.
3. Limitations: None.
4. Subroutine Usage: CALL RANDY (R).
5. Input Card: START card.
   a. The START card contains 68 random digits in columns 1 to 68. Within these 68 digits strings of zeros in excess of two should not occur.
   b. In columns 69-72 of the card should be four digits sampled at random and with replacement from 1, 3, 7 and 9.
   c. This START card is read in by the subroutine itself. This read occurs only the first time

the subroutine is called. It is recommended that RANDY be called once early in execution so that the READ statement will be executed at a predictable time and thereby data synchronization problems avoided.

6. Output: The value returned (R) will be a floating-point number between 0.0 and 1.0.

7. Subroutines required: None.

III. Mathematical Methods and References

a. Seventeen generators each operating under the power residue method are in RANDY. The random number generated on call i is used to select which of the seventeen generators will be used on call i+1.

b. The cycle of each generator is 8192.

c. Also see: Evans, S. H. The generation of pseudo-random numbers for the IBM 1800. Working paper #1. Institute for the Study of Cognitive Systems, Texas Christian University, 1968.

IV. Listing of Source Program

Attached.

V. Sample Output

Attached.

VI. Remarks

Using four randomly selected START cards, four Chi square tests were performed, each involving the

generation of 20,000 random numbers and 128 degrees of freedom

<u>Test #1. Chi square/df = .900 ; 22nd percentile</u>

<u>Test #2. Chi square/df = .725 ; 1st percentile</u>

<u>Test #3. Chi square/df = .937 ; 30th percentile</u>

<u>Test #4. Chi square/df = .917 ; 37th percentile</u>

It should be noted that these numbers tend to fall on the low side of the Chi square distribution indicating that the numbers generated by RANDY tend to be more evenly distributed in the unit interval that you would expect when randomly sampling from a rectangular distribution.

RANDY was also tested for cycling and none was found in the first 100,000 numbers. The criterion for cycling was repetition of the second through the eleventh numbers.

```
RAN
DMP FUNCTION COMPLETED
// FOR    30 JUN 71 13.478 HRS
*NONPROCESS PROGRAM
*ONE WORD INTEGERS
*LIST ALL
      SUBROUTINE RANDY(RR)
      DIMENSION KU(17),KC(17),KL(4)
      DATA NDUM, KC     /1,899,835,957,877,915,861,947,925,867,909,883,
     1851,941,893,931,845,963/
      GO TO (15,16),NDUM
   15 READ(2,19)(KU(I),I=1,17),(KL(J),J=1,4)
   19 FORMAT (17I4,4I1)
      J=0
      DO 13 I=1,17
      J=J+1
      KU(I)=KU(I)*10+KL(J)
      IF(KU(I))21,22,22
   21 KU(I)=KU(I)+32767+1
   22 IF(J-4)13,11,11
   11 J=0
   13 CONTINUE
      R=KU(1)
      R=R/32768.
      NDUM=NDUM+1
   16 K=R*16.99+1.0
      IR=KU(K)*KC(K)
      IF(IR)23,24,24
   23 IR=IR+32767+1
   24 R=IR
      R=R/32768.
      KU(K)=IR
      RR=R
      RETURN
      END

VARIABLE ALLOCATIONS
     R(R  )=0000          KU(I  )=0012-0002    KC(I  )=0023-0013    KL(I  )=0027
     J(I  )=002A           K(I  )=0028          IR(I  )=002C

STATEMENT ALLOCATIONS
 19   =003D  15   =004D  21   =00A0  22   =00AD  11   =0083  13   =0087  16

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS

CALLED SUBPROGRAMS
 FADD    FMPY    FDIV    FLD     FSTO    IFIX    FLOAT   COMGO   ISTOX   MRI

REAL CONSTANTS
  .327680E 05=0030    .169900E 02=0032    .100000E 01=0034

INTEGER CONSTANTS
```

```
     2=0036      1=0037      17=0038      4=0039      0=003A      10=003B  32
CORE REQUIREMENTS FOR RANDY
 COMMON        0  INSKEL COMMON        0
  VARIABLES       48   PROGRAM     222


END OF COMPILATION
```

VALUES RETURNED FROM RANDY

0.46206670
0.97213757
0.60293591
0.33059698
0.09817506
0.82565319
0.71530163
0.06094361
0.42031866
0.22714236
0.80990612
0.48190313
0.71408092
0.34793096
0.52871716
0.10806275
0.96603405
0.62716686
0.91708385
0.30319219
0.22537234
0.28756719
0.87167370
0.94570934
0.96157848
0.99996960
0.97061169
0.69894421
0.26358038
0.58132946
0.74215710
0.40298467
0.22409060
0.19638064
0.22579959
0.02621460
0.07809449
0.63833630
0.78494274
0.33944708

I. Identification

1. Subroutine Name: PATØT

2. Category: Pattern Construction

3. Purpose: Output a 48 x 48 matrix in two symbols.

4. Date: July, 1968

5. Programmers: S. H. Evans, Bob Breckenridge.

II. Use Information

1. Language: 1800 Basic FØRTRAN IV.

2. Machine: IBM 1800, 32K, 16 bit words.

3. Limitations: Accepts fixed point 48 x 48 matrix. Positive numbers are output by over-printing a zero by an asterisk. Zero or negative numbers are output as a blank space.

4. Subroutine Usage: CALL PATØT (MX, NI, NJ)

5. Subroutine Parameters:

   MX: Matrix to be output. Must be dimensioned to 48 x 48.

   NI: Number of rows to output.

   NJ: Number of columns to output.

6. Subroutines Required: None.

III. Mathematical Methods and References

Not Applicable.

IV. Listing of Source Program

Attached.

V. Sample Run

Attached.

VI. Remarks

None.

```
JOIN
DMP FUNCTION COMPLETED
// FOR    30 JUN 71 13.732 HRS
*LIST ALL
*ONE WORD INTEGERS
*NONPROCESS PROGRAM
      SUBROUTINE PATOT(MX,NI,NJ)
C     ACCEPTS MATRIX MX(NI ROWS, NJ COLUMNS)
C     AND PRINTS ALL POSITIVE ENTRIES AS BLACK SPOTS,
C     BY OVER PRINTING CHA AND CHB FOR BLACK AND CHC FOR WHITE.
      DIMENSION MX(48,48), T(48), S(48)
      DATA CHA,CHB,CHC/'0','*',' '/
      DO 100 I=1, NI
      DO 50 J=1, NJ
      IF(MX(I,J))30, 30, 40
   30 T(J)=CHC
      S(J)=CHC
      GO TO 50
   40 T(J)=CHA
      S(J)=CHB
   50 CONTINUE
      WRITE (3,51)(T(J), J=1, NJ)
   51 FORMAT (1H 48A1)
      WRITE (3,52)(S(J), J=1, NJ)
   52 FORMAT (1H+48A1)
  100 CONTINUE
      RETURN
      END

VARIABLE ALLOCATIONS
     T(R )=005E-0000      S(R )=00BE-0060   CHC(R )=00C0        CHA(R )=00C2
     J(I )=00C7

STATEMENT ALLOCATIONS
 51    =00CC  52    =00D1   30    =00F4   40    =0105   50    =0114   100   =014B

FEATURES SUPPORTED
 NONPROCESS
 ONE WORD INTEGERS

CALLED SUBPROGRAMS
 FLD      FSTOX    MWRT     MCOMP    MIOFX    SUBSC    SUBIN

INTEGER CONSTANTS
     1=00CA        3=00CB

CORE REQUIREMENTS FOR PATOT
 COMMON        0  INSKEL COMMON        0
  VARIABLES     202   PROGRAM     140



END OF COMPILATION
```

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13. ABSTRACT

This document describes a collection of computer programs developed for use in research on human pattern perception. The overall orientation which guided the development of the VARGUS (Variable Generator of Unfamiliar Stimuli) pattern-generation programs and the historical backgrounds of each category (VARGUS 7, 9 and 10) are related in the first section. The second section provides documentation, sample output and summary for each program and subroutine.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Pattern Recognition	8	3				
Photointerpretation	8	3				
Image Interpretation	8	3				
Man-Machine Decision Making	8	3				
Feature Space	8	3				
Feature Selection	8	3				
Personnel Selection	8	3				